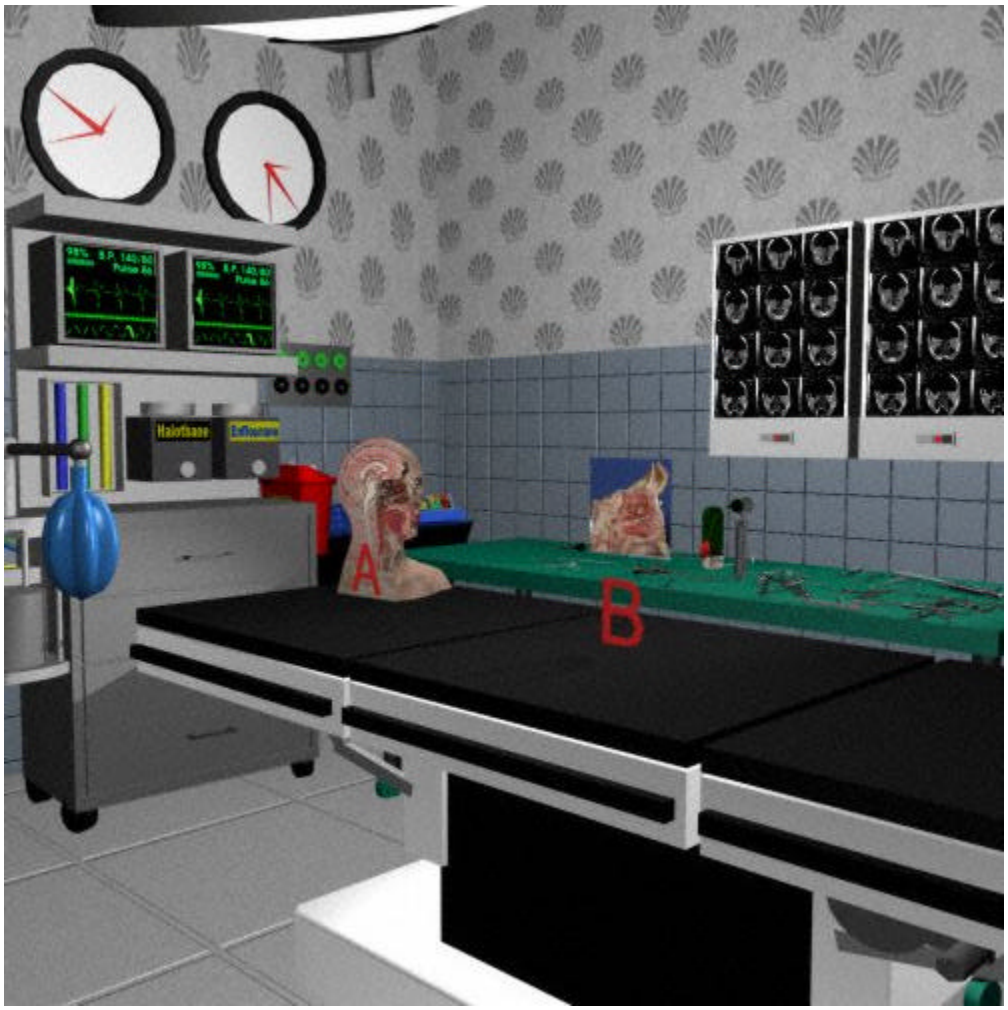
ARS Patient Information Series

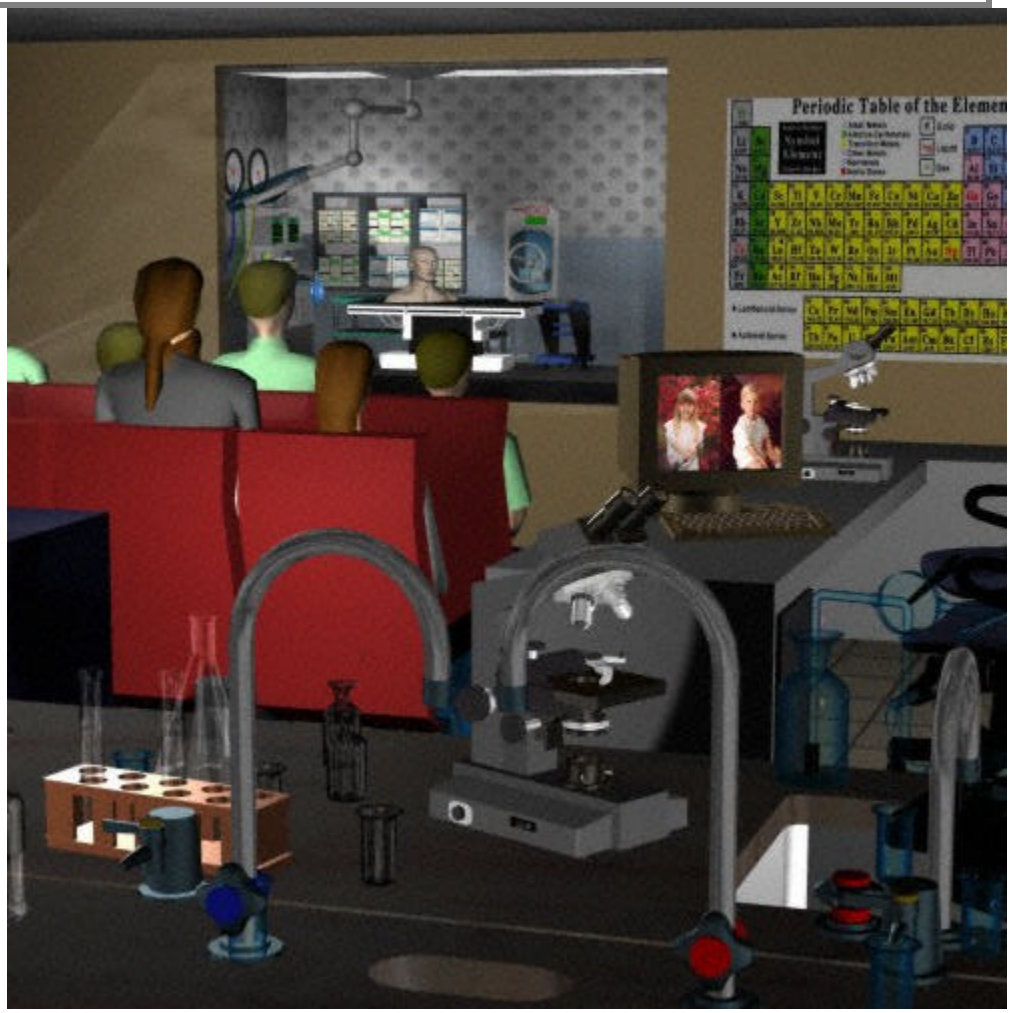
Virtual Sinus Anatomy

Peter Casano, M.D.

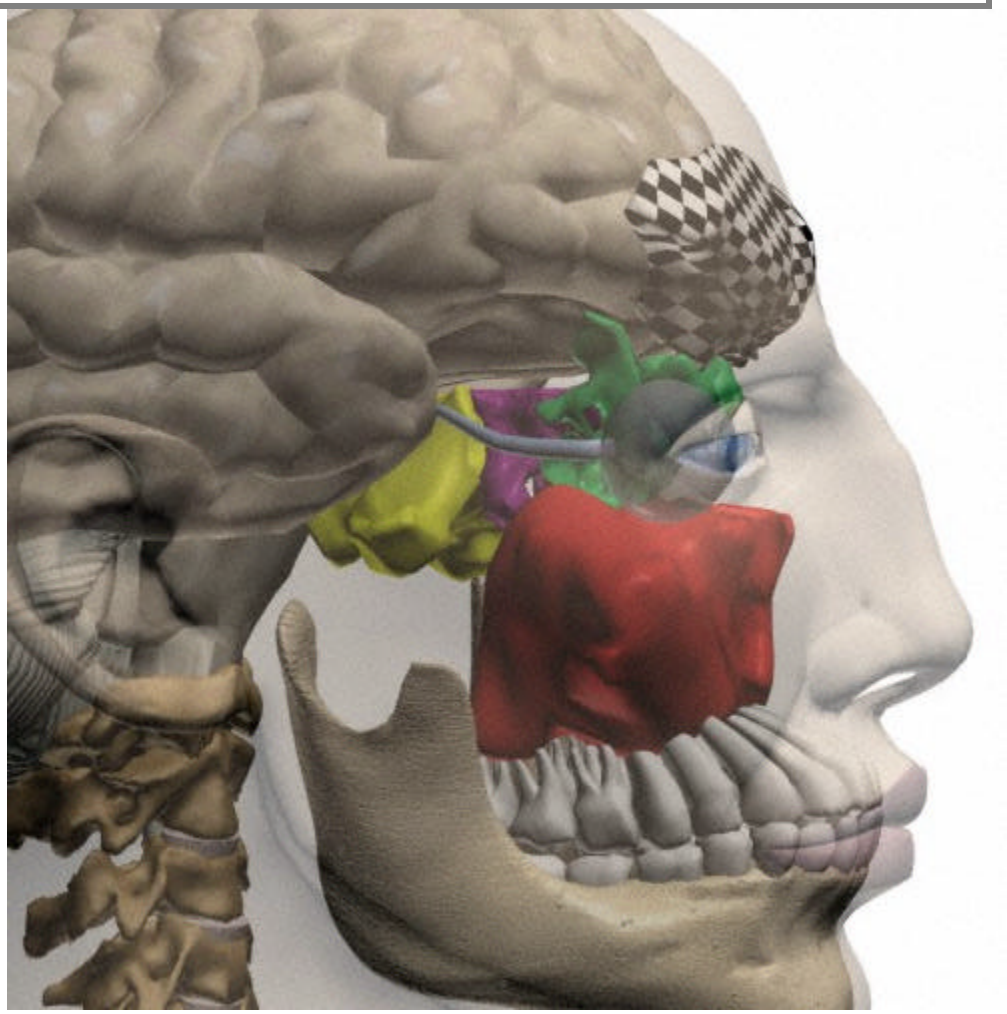
Welcome to my virtual sinus laboratory.
These images are from the virtual reality environment that I have created. Its purpose is to help explain sinus and nasal topics to patients, primary care physicians, and specialists. In my lectures, participants wear polarized glasses to decode the 3D images from special projectors, giving a true 3D stereoscopic experience.



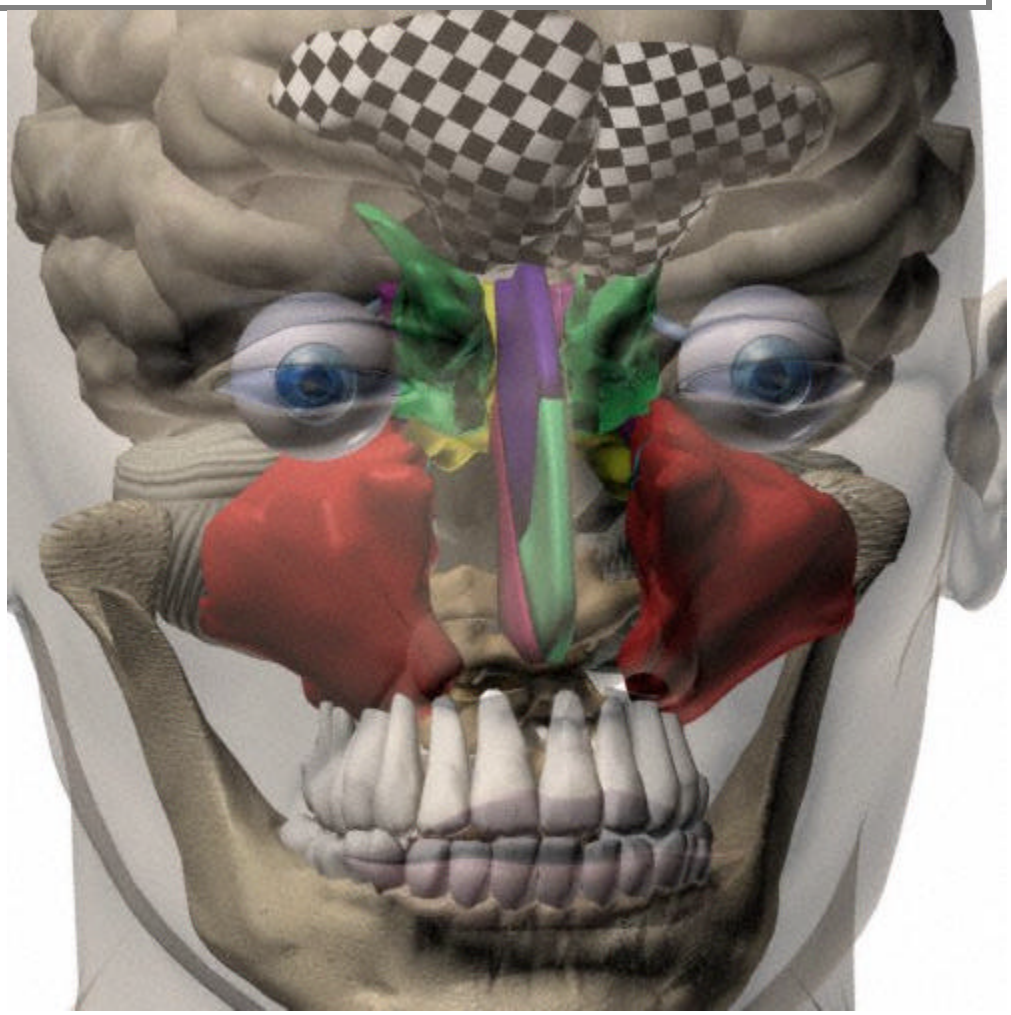
The Lab.
Similar images comprise my advanced sinus anatomy course. Full motion computer animations are projected with a state-of-the-art stereoscopic projector. This lecture has been shown to sinus surgeons around the country and it has allowed me to participate in education programs that advance the field of sinus and nasal medicine. These images orient the viewer to my virtual environment and examine the basics of sinus anatomy and physiology.



Sinus 1.
The sinuses are air spaces within bone. There are several groups of sinuses. A close up of the main computer model is seen from the side view. The frontal sinus is black check, the maxillary sinus is red, the anterior ethmoid sinuses are green, the posterior ethmoid sinuses are purple, and the sphenoid sinus is yellow.

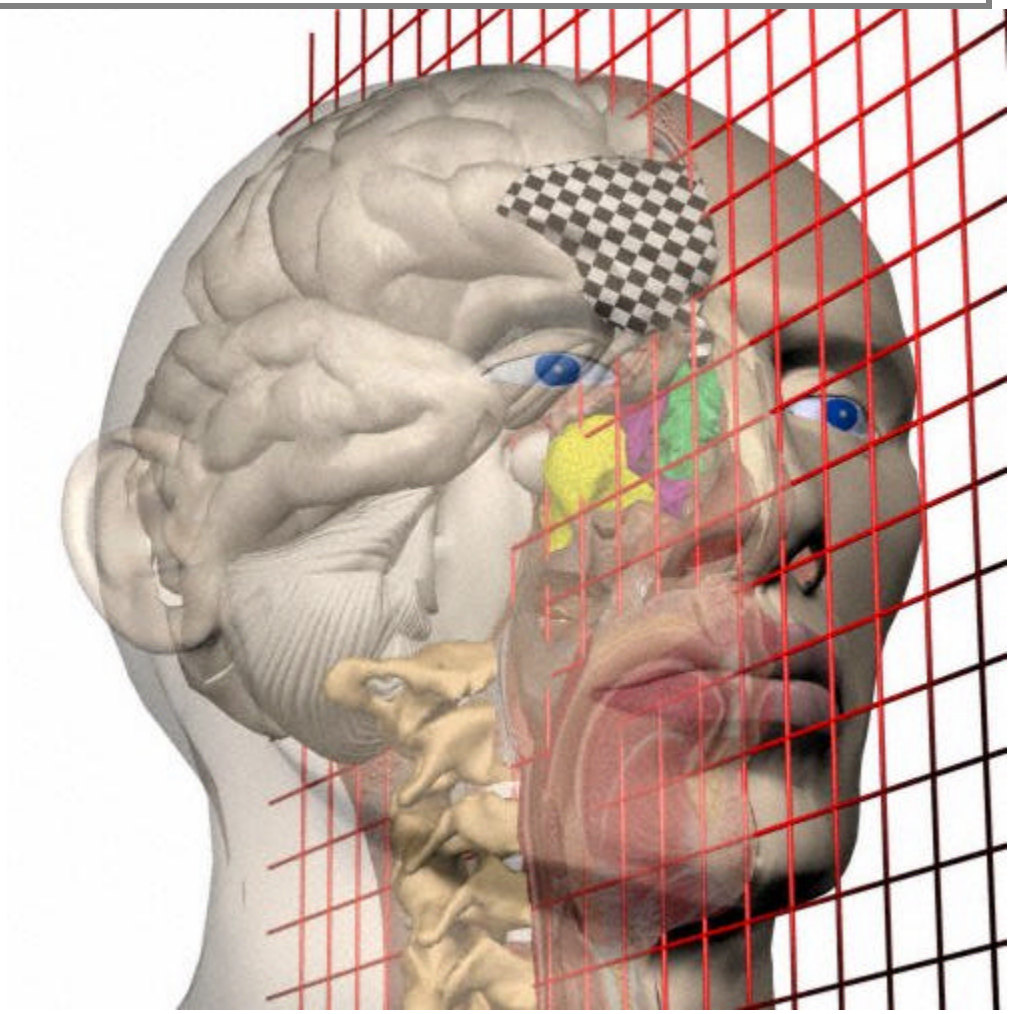


Sinus 2.
Another view of the main computer model as seen from the front. The frontal sinus is black check, the maxillary sinus is red, the anterior ethmoid sinuses are green, the posterior ethmoid sinuses are purple, and the sphenoid sinus is yellow.

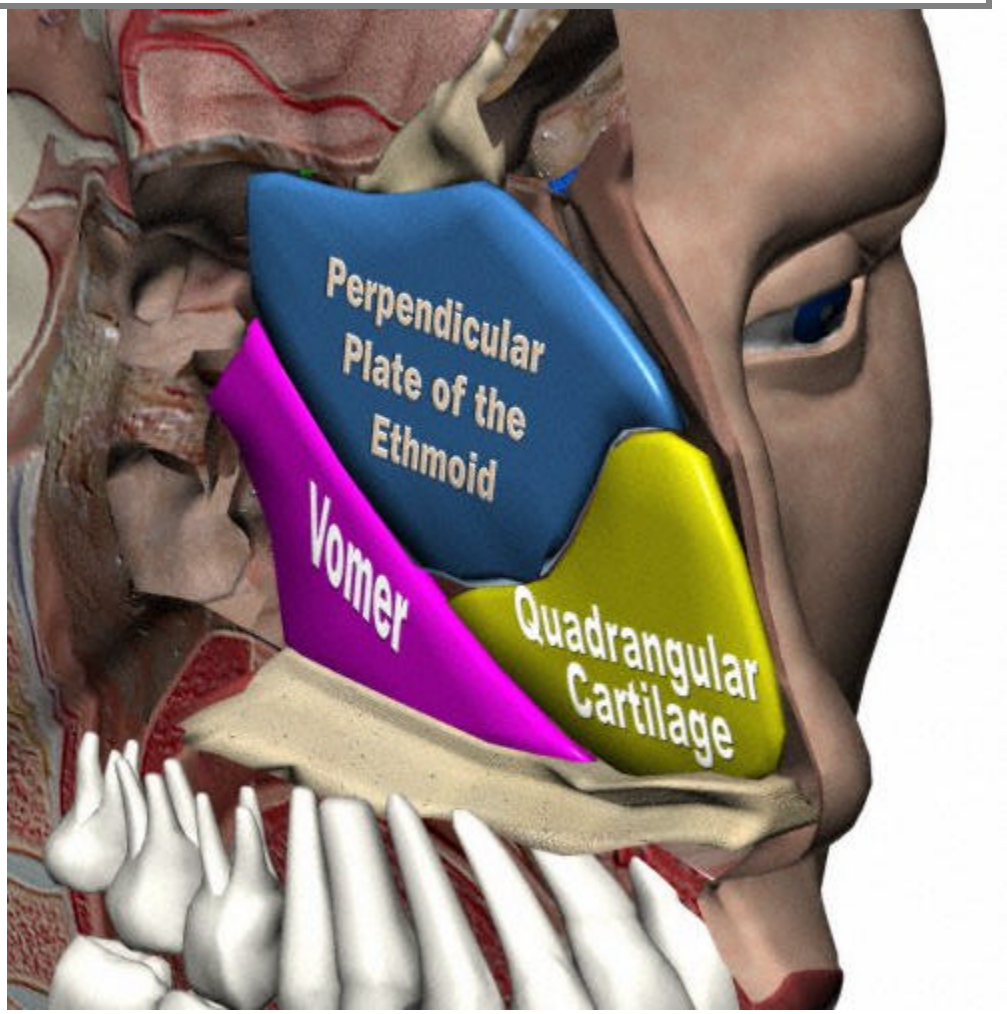


Sinus 3.

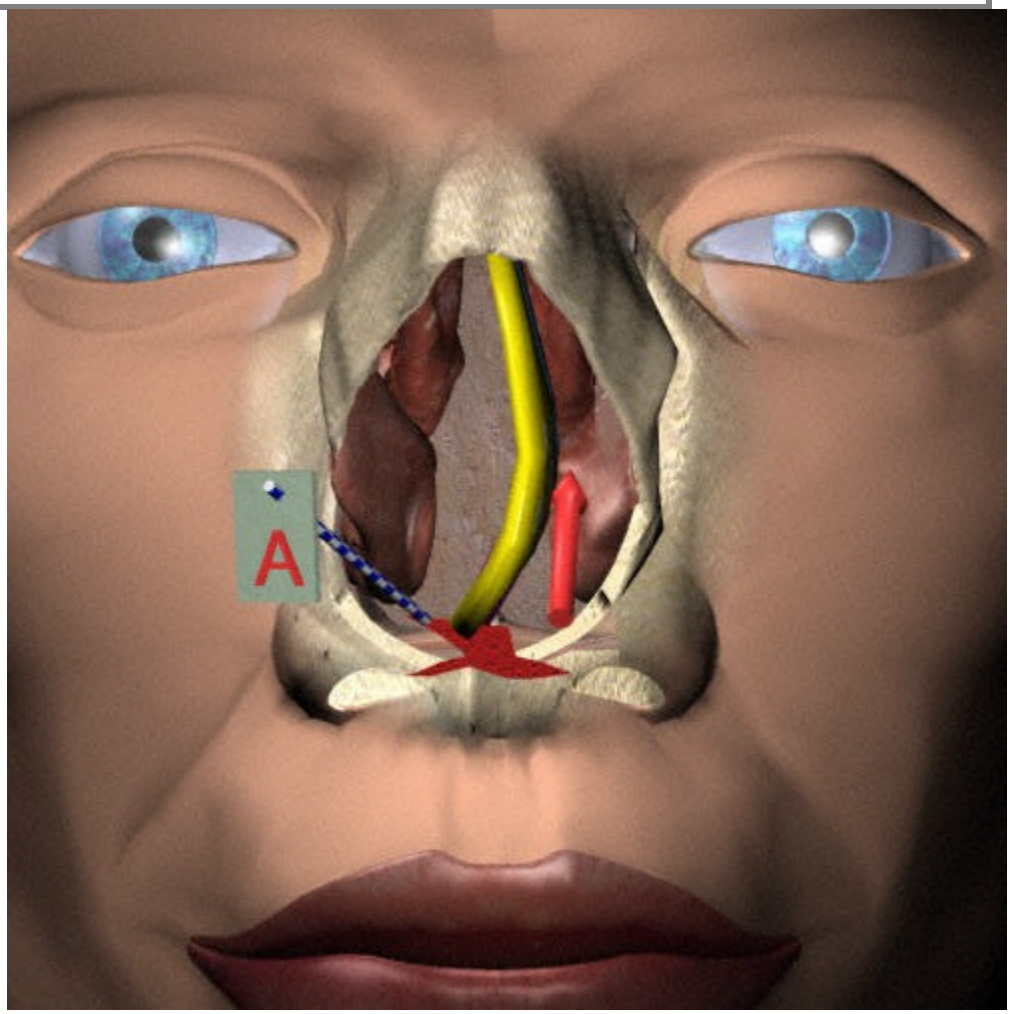
For most structures the anatomy is easier to examine if we concentrate on only one half of the specimen. Many of the following views have the right side of the specimen removed. The mid-sagittal plane is seen. We will concentrate on the left half of the specimen for most of the remaining views.



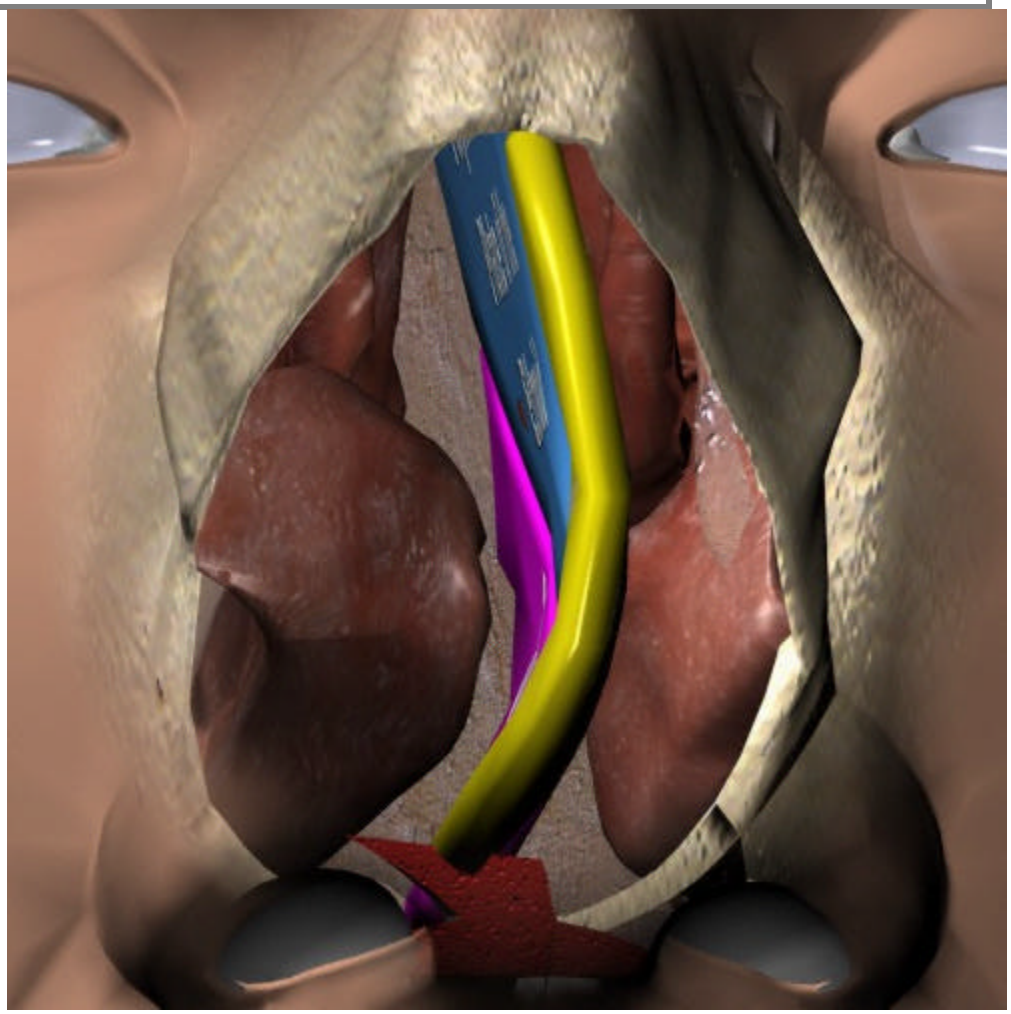
The Septum.
The nasal septum separates the left and right nasal airway. The yellow portion is made of flexible cartilage, the quadrangular cartilage. The blue portion is thin bone, the perpendicular plate of the ethmoid bone. The purple portion is thicker bone, the vomer bone.



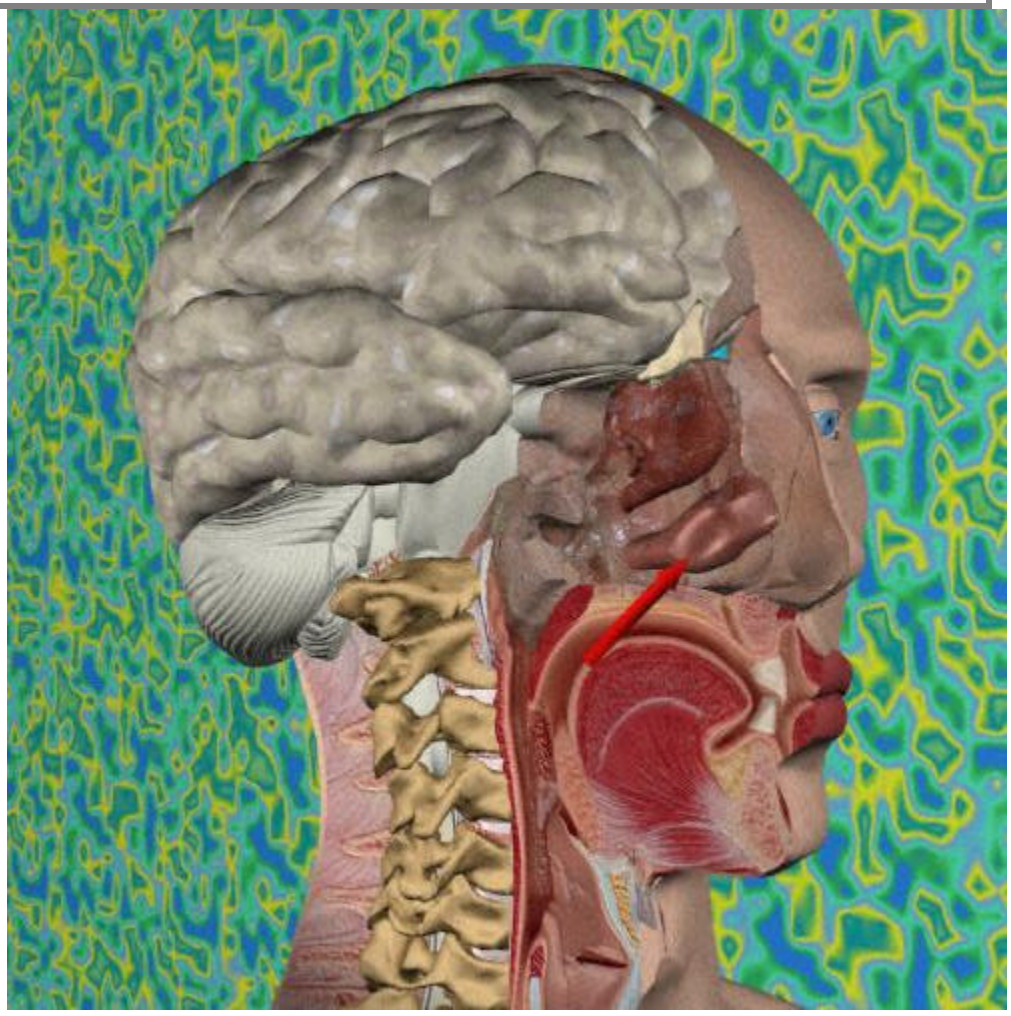
Deviation 1.
Much of the airflow through the nose occurs through the narrow space between the septum and the inferior turbinate A common cause of nasal airway obstruction is called a nasal septal deviation. This is a view of the nasal passage with the external nose removed. The septum can narrow this space on one side if it is deviated to that side. A ridge of bone that can often narrow the opposite side is seen.



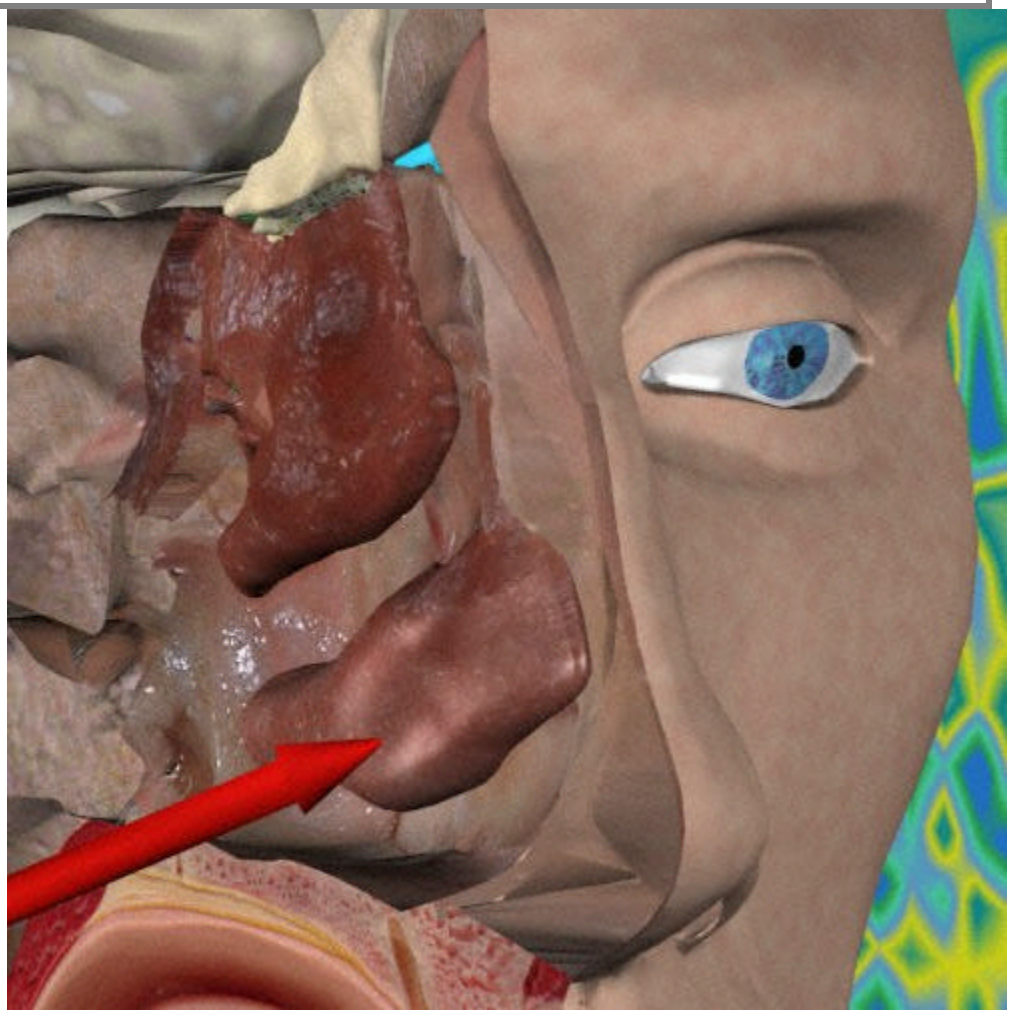
Deviation 2.
The inferior turbinates tend to grow to fill the available space. Long standing septal deviations can cause the inferior turbinate to enlarge on the concave side of the deviation. Often, the concave side of the deviation seems more obstructed to the patient. This may be from an enlarged turbinate or from turbulent airflow on this side. Several methods are available to reduce the size of enlarged turbinates and increase the available breathing space.



Turbinate 1.
The inferior turbinate is large and fills the lower portion of the nasal airway. It is a long structure, and extends from the front of the nose to the rear. The turbinate functions to humidify the air, it shrinks and swells to regulate nasal air resistance, and it collects airborne particles on its surface to clean the air.

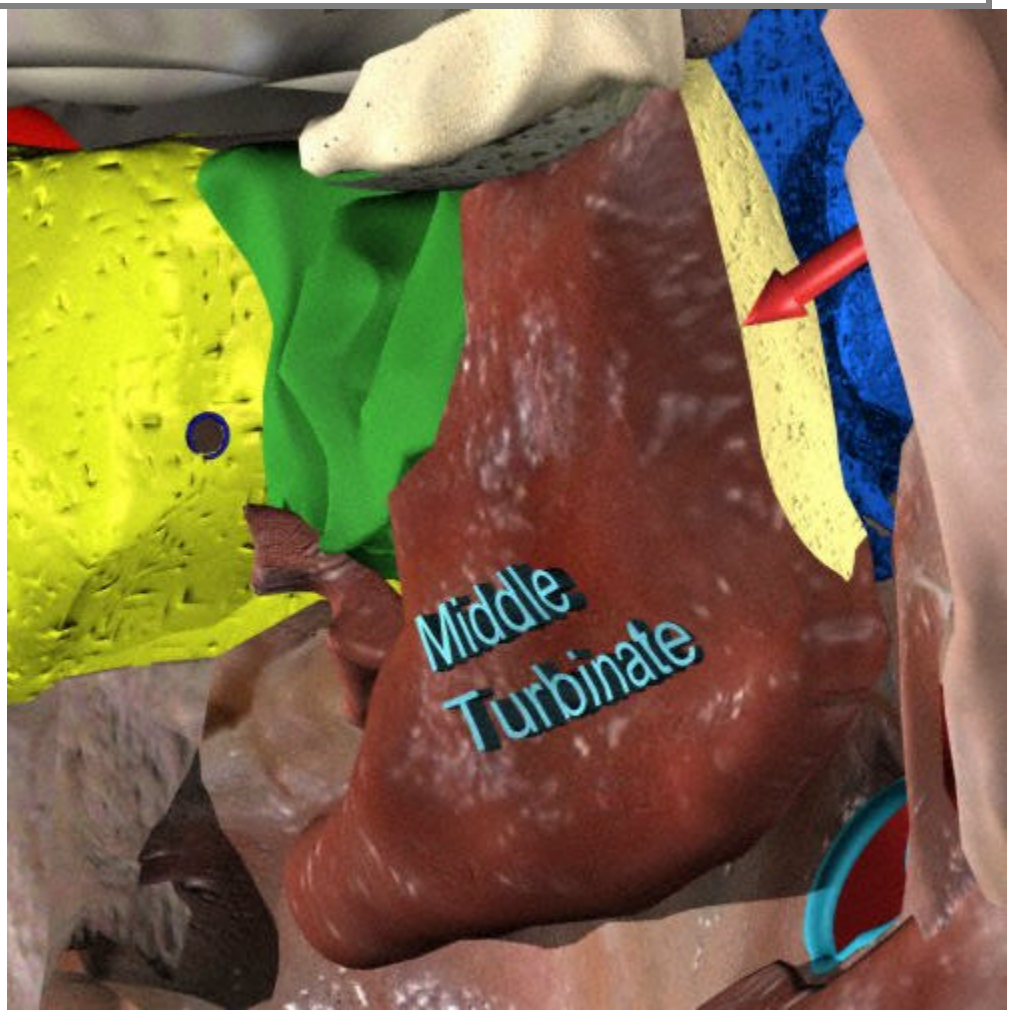


Turbinate 2.
The inferior turbinate is that structure which can shrink and swell dramatically. If you use Afrin or other decongestants, the inferior turbinate is the structure most affected. When a cold causes severe congestion, this is one of the primary structure that has swollen.

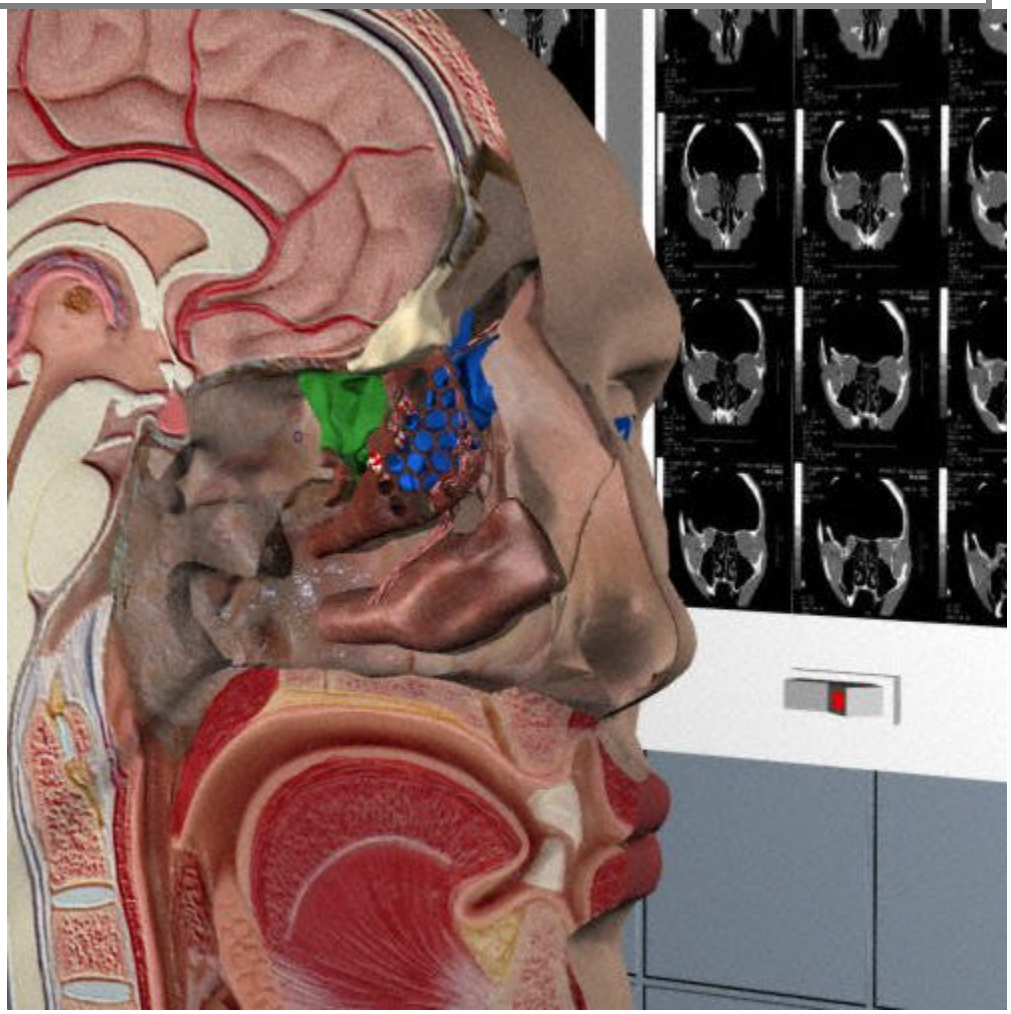


Turbinate 3.
The anterior half of the middle turbinate acts like an awning. It provides a location free from rapid airflow and airborne particles for the anterior sinuses to open into. The space under the middle turbinate is called the middle meatus. The front of the middle turbinate can be mistaken for a polyp on nasal exam. It may be necessary to apply a topical decongestant to visualize the middle turbinate.

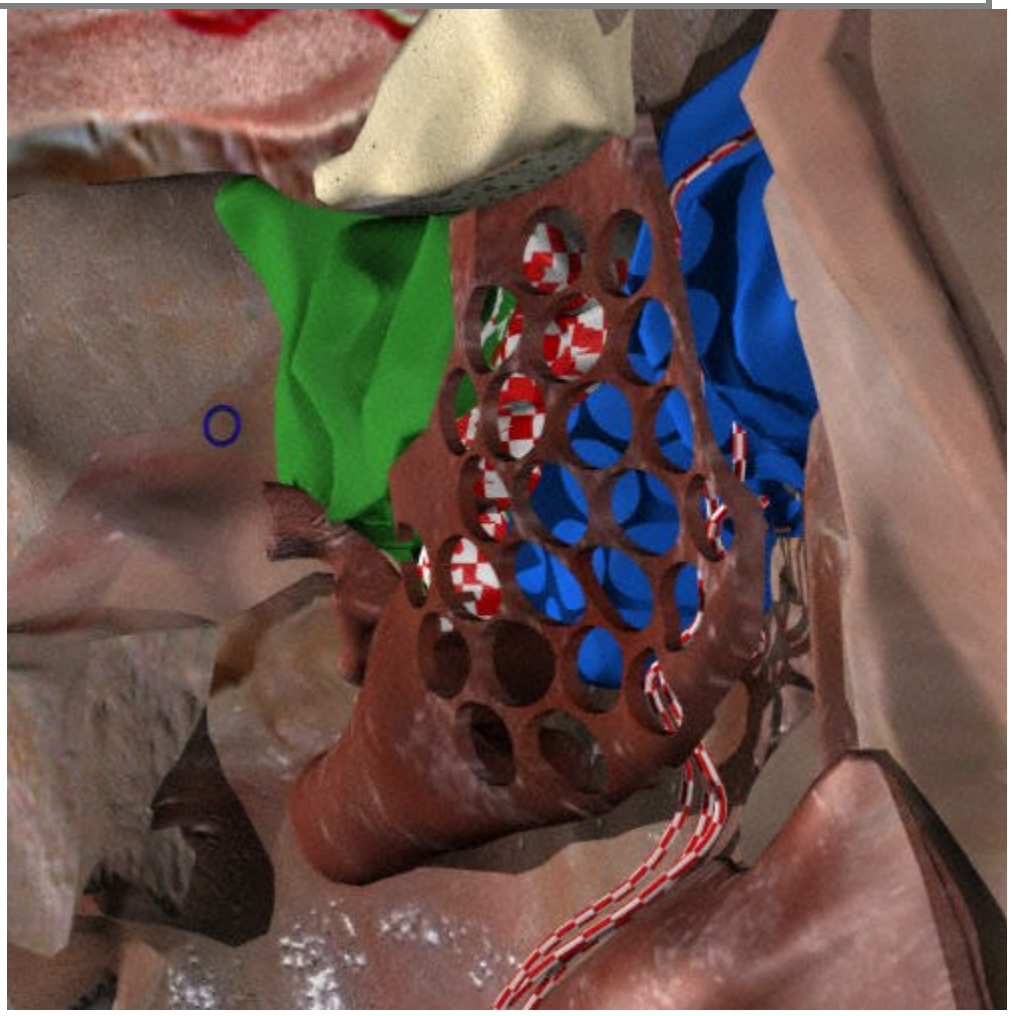
Concha B.
Occasionally the middle turbinate has a bubble formed in its interior portion. This is called a concha bullosa and is a common anatomic variation. Large concha bullosa can contribute to sinus congestion and sinus pain. The very front portion is removed to show the interior of the concha bullosa.



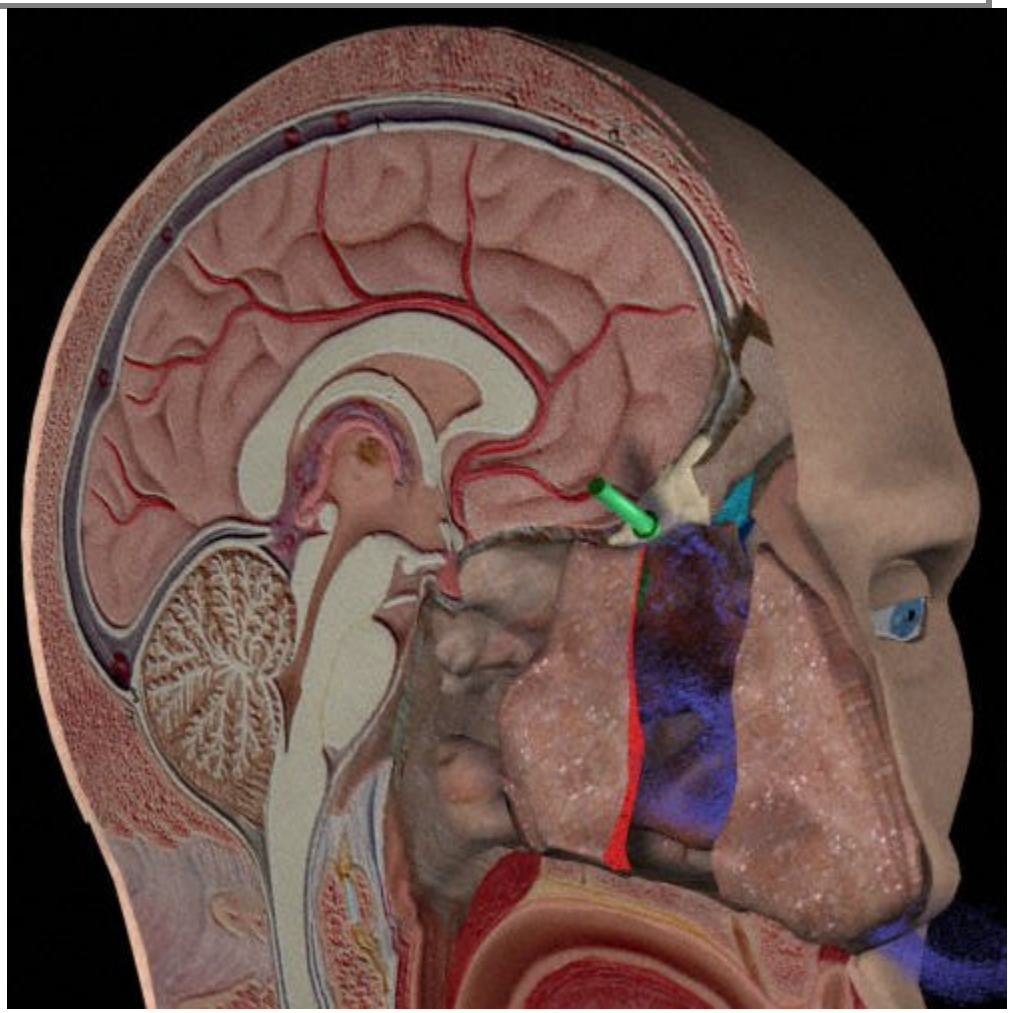
Turbinate 4.
The middle turbinate is a key landmark during sinus examination and surgery. Holes have been drilled into the middle turbinate to help us see through it. It can usually be seen if the nose is decongested with spray. The anterior sinuses lie lateral to the middle turbinate. The frontal sinus, maxillary sinus, and anterior ethmoid sinuses drain out from under the middle turbinate.



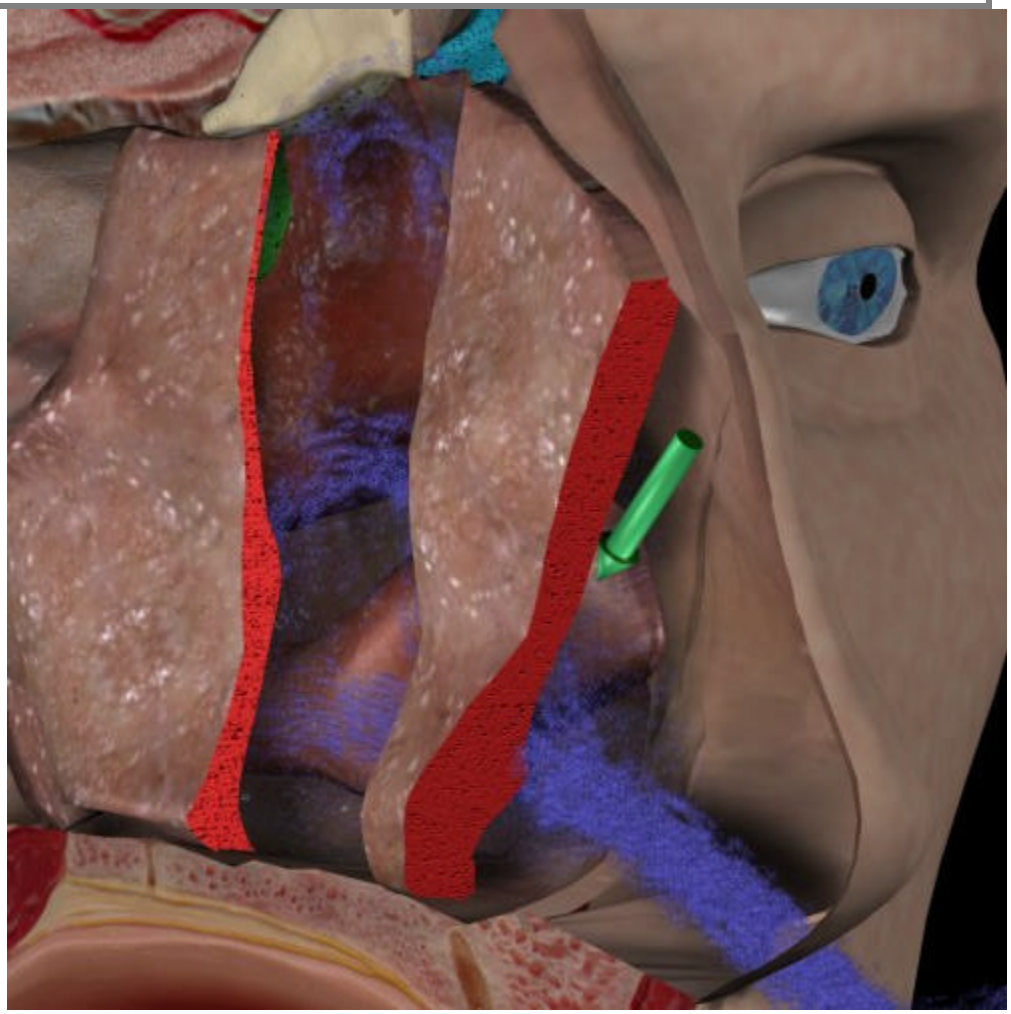
Turbinate 5.
One part of the middle turbinate is called the basal lamella. It is shown in red checkers. This portion forms a wall that separates the anterior ethmoid cells from the posterior ethmoid cells. The face of the sphenoid sinus has been removed but the opening is shown.



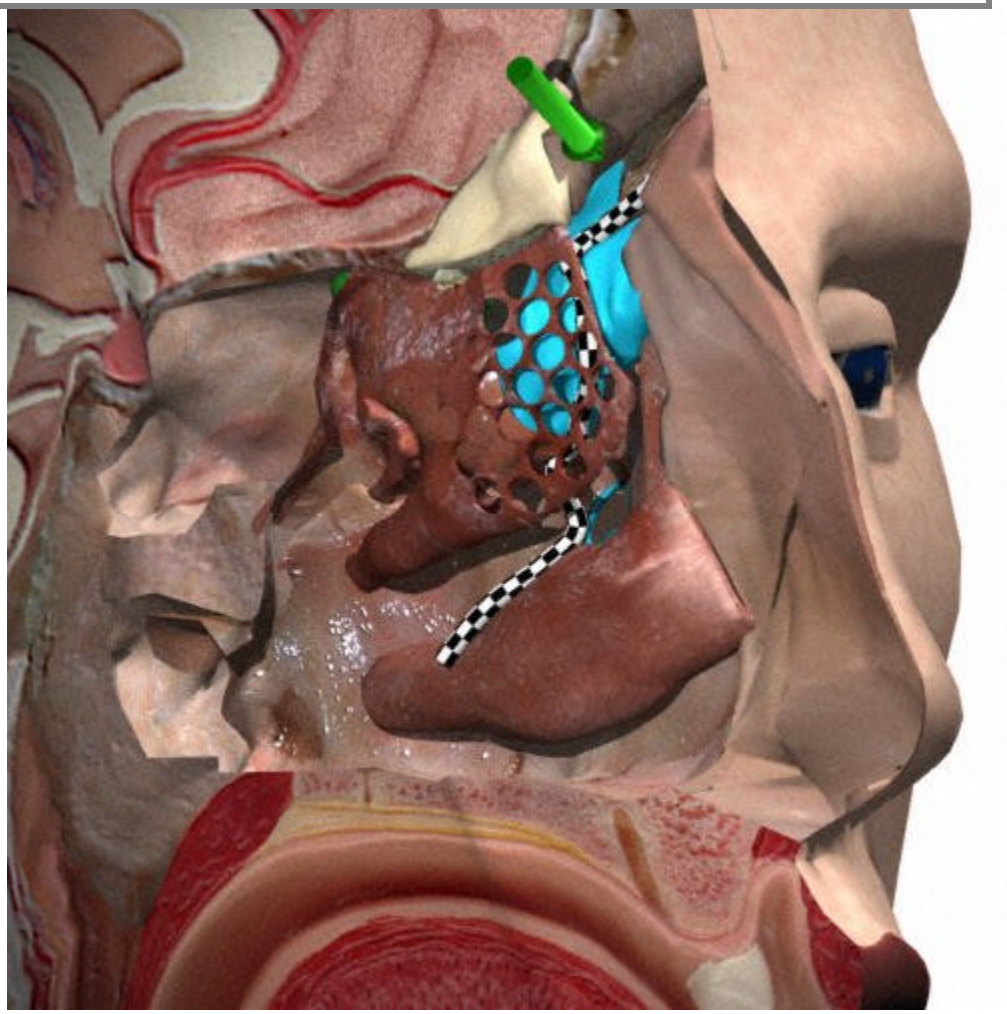
Airflow 1.
Air flows both along the floor of the nose between the septum, and the inferior turbinate, and higher in the nose near the middle turbinate. Some air reaches the highest point in the nasal passage where the smell receptors are located.



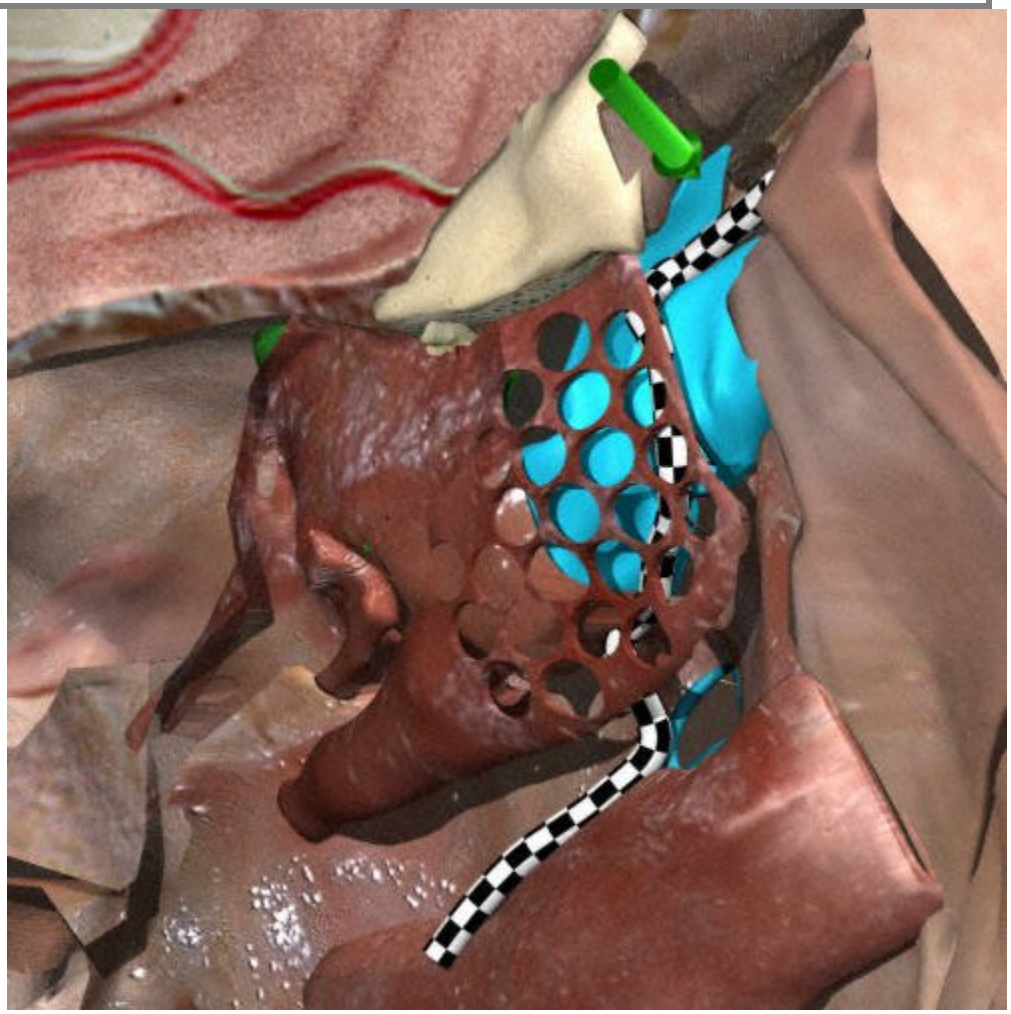
Airflow 2.
The septum is partially removed. The most narrowed portion is just inside the nostril. The plane of this cut-away is roughly the location of the nasal valve. This “valve” is the narrowest cross section of the nasal airway. Swelling here or deviations of the septum can easily cause obstructions.



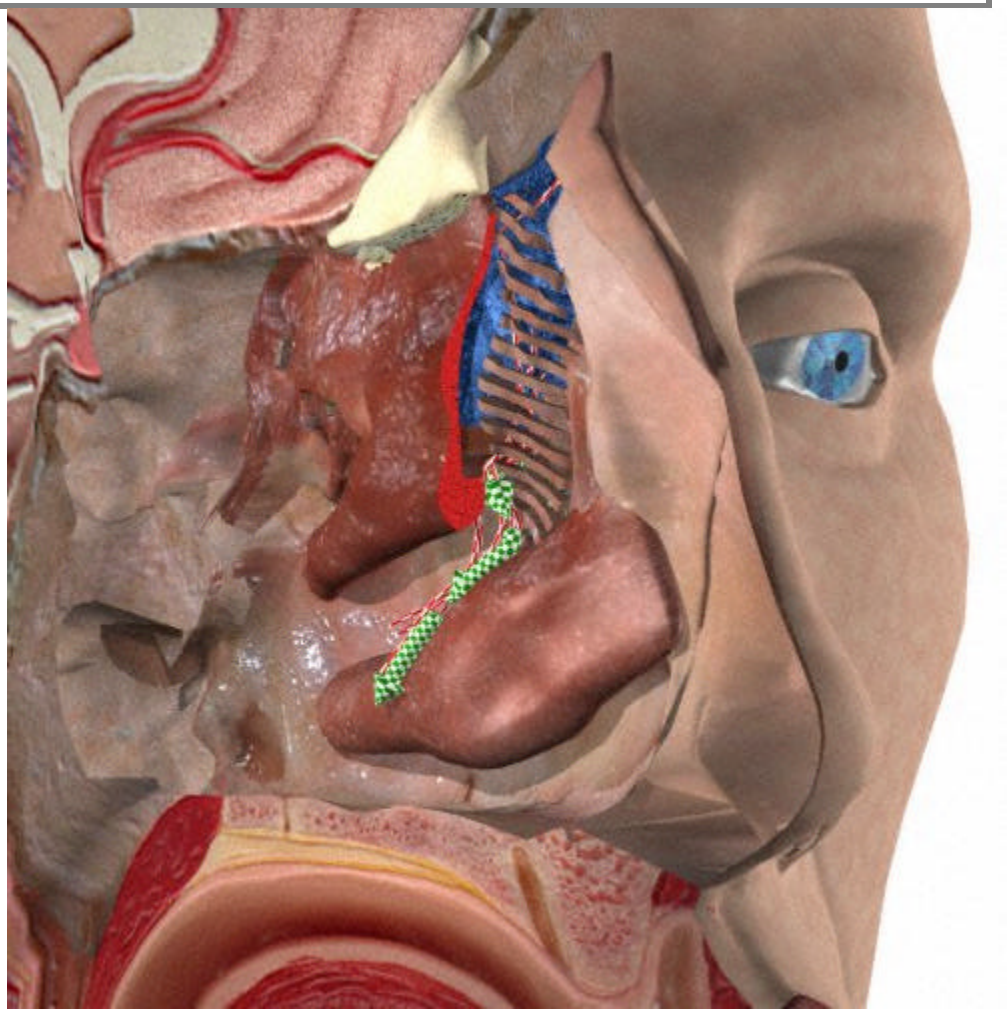
Frontal 1.
The frontal sinus has the longest drainage pathway. Surprisingly, the frontal sinus is not as frequently involved as the maxillary or anterior ethmoid sinuses. The frontal sinus outflow is obstructed to a variable degree by the anterior ethmoid cells.



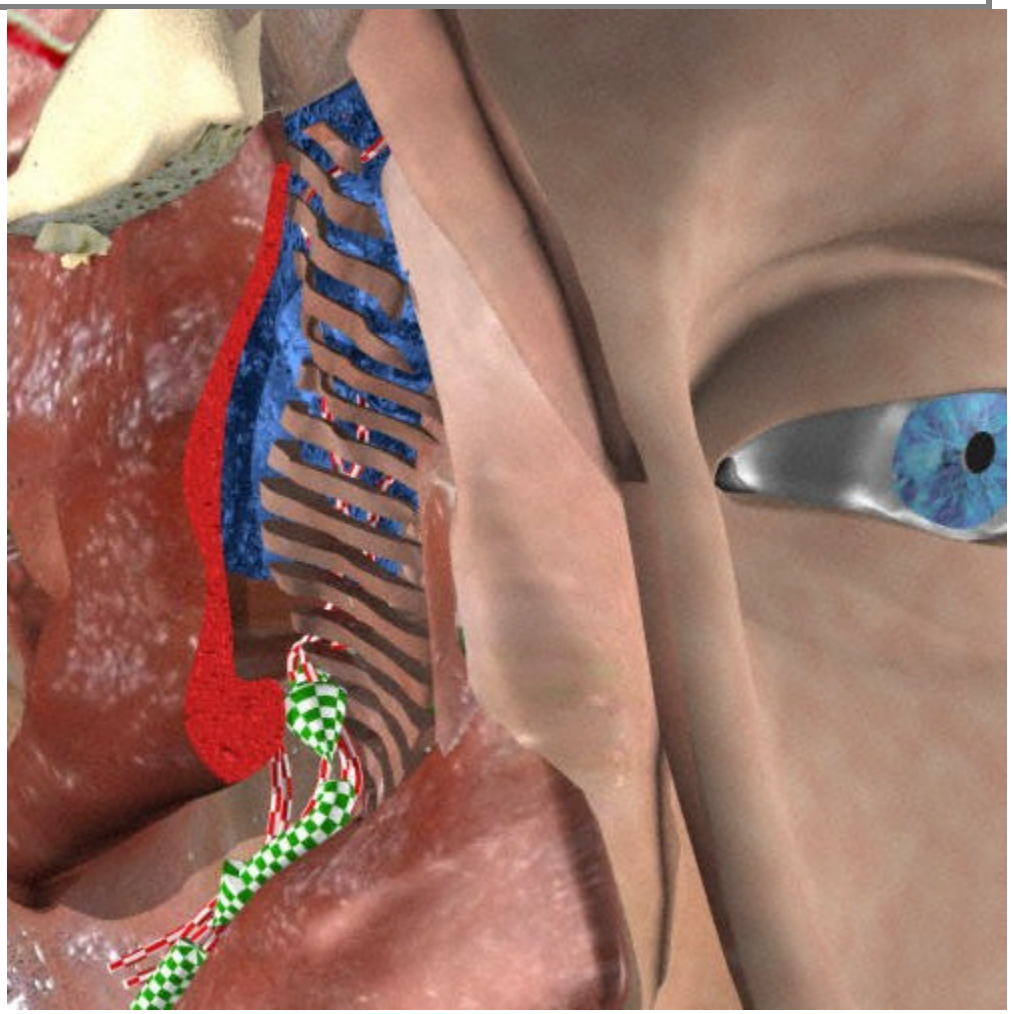
Frontal 2.
The arrow points to an area called the frontal recess. This is one of the most common regions for residual infection after sinus surgery. Special instruments and training are needed to adequately address obstructions here. Even when special care is taken to examine and protect this area, frontal sinus obstruction can be difficult to correct.



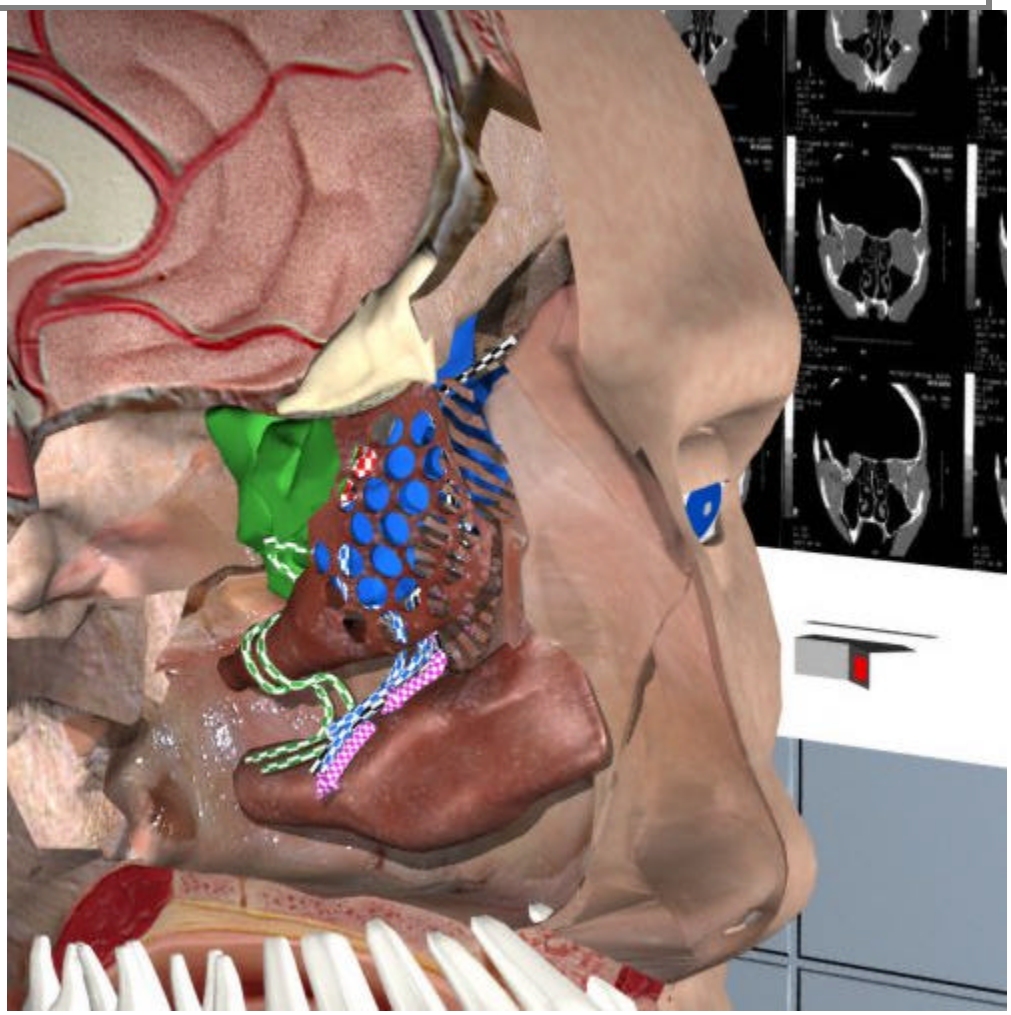
Uncinate 1.
The uncinate bone is shown with slots drilled to help see the other side. The middle turbinate is partially removed. The frontal sinus and anterior ethmoid cells drain into a space just inside of the uncinate bone. This space diverts drainage back so that it will be directed down the throat for swallowing. The drainage crosses over the free edge of the uncinate bone and mixes with the drainage coming from the maxillary sinus. The final common path is over the surface of the inferior turbinate.



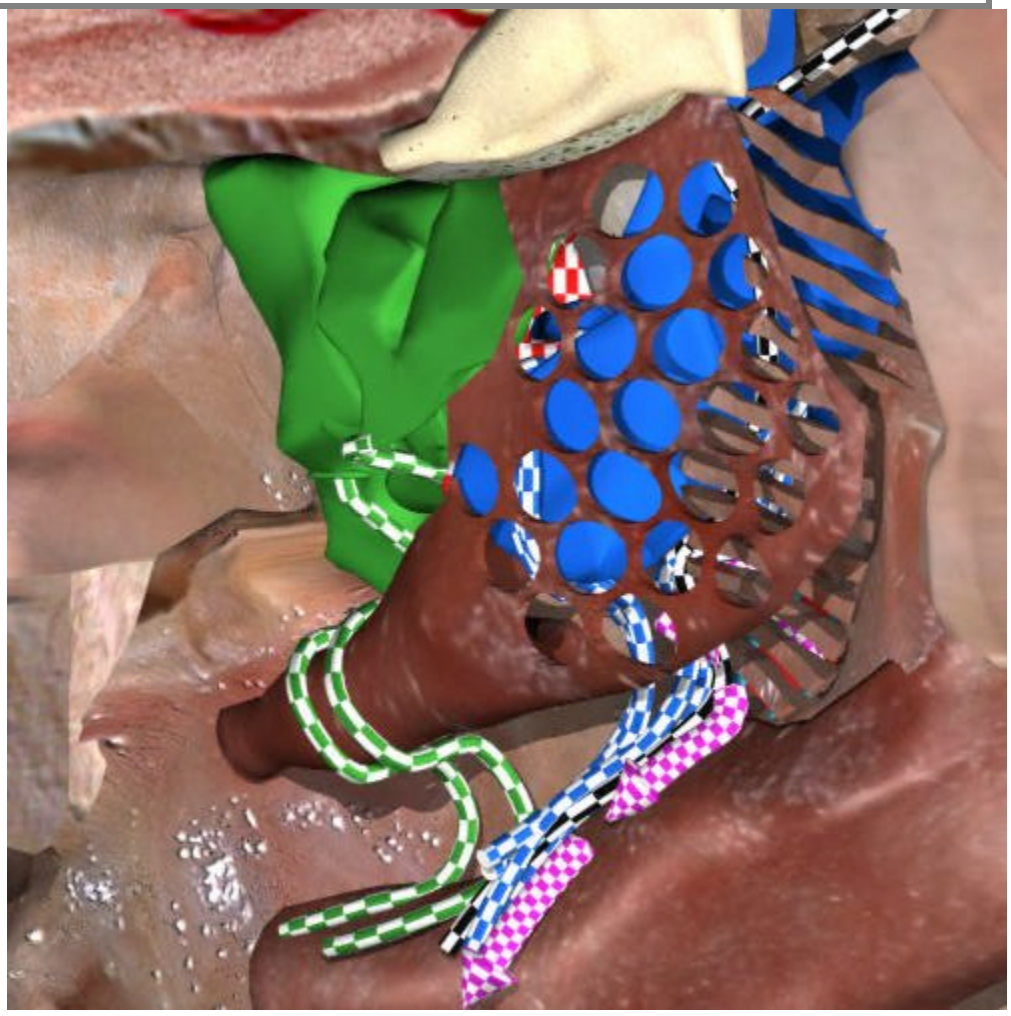
Uncinate 2.
The flow from the anterior sinuses can be seen traveling along the inside surface of the uncinate process through the slots. This space can be very narrow and is often a site of obstruction. By removing the uncinate, the available drainage space is increased. It is also necessary to remove the uncinate to be able to access the ethmoid sinuses and the maxillary sinus opening with endoscopic instruments.



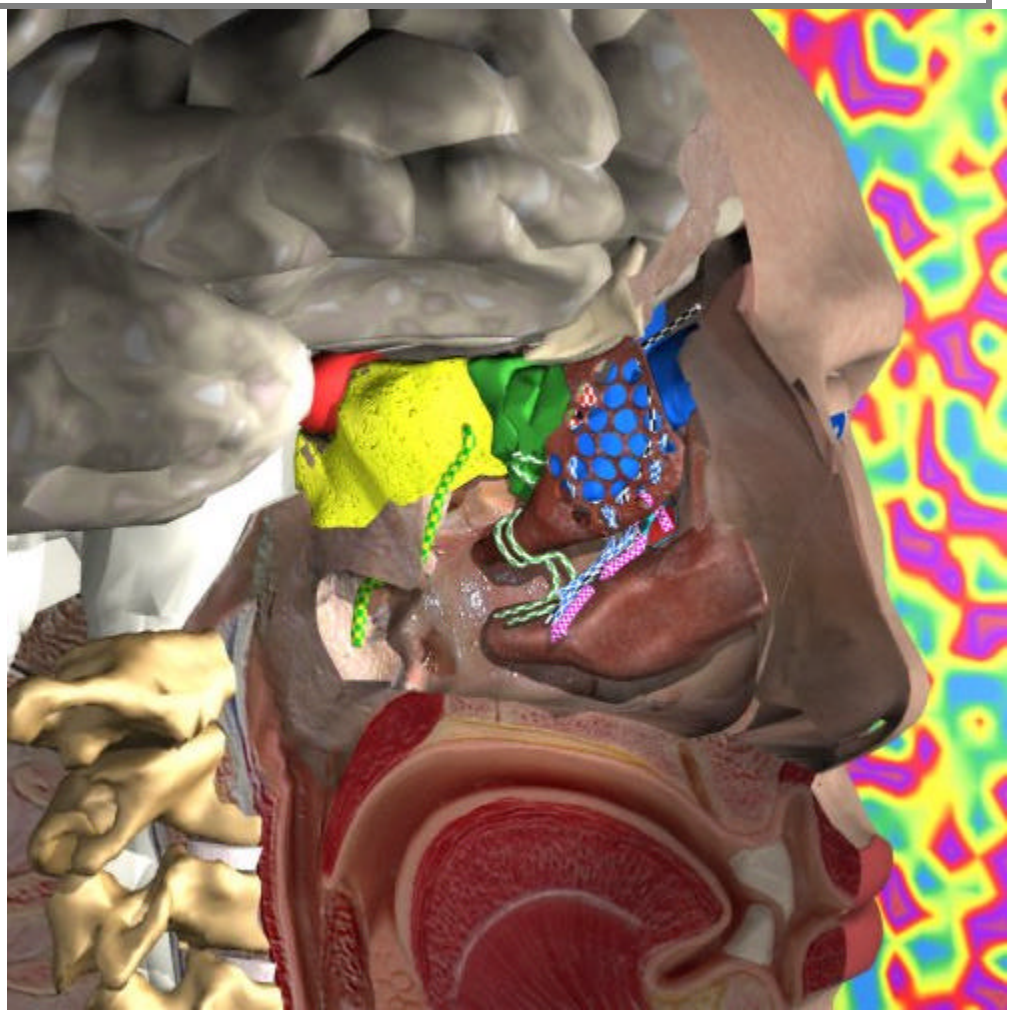
Drainage 1.
The posterior ethmoid cells drain into a different location. Their secretions exit above the middle turbinate and behind the portion of the middle turbinate called the basal lamella (red check).



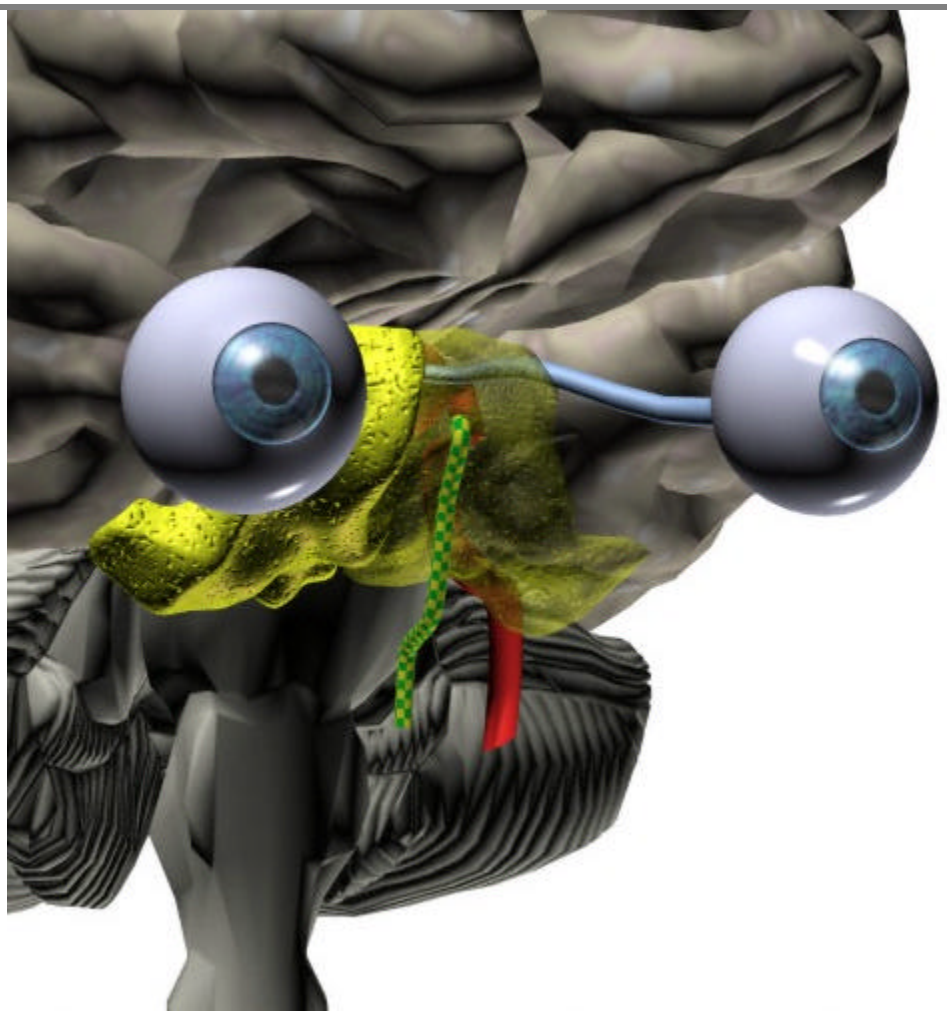
Drainage 2.
Since the posterior ethmoids have an independent drainage route, they are not always involved with the obstructions seen in the anterior ethmoid, frontal, and maxillary sinuses. Disease processes that involve all of the sinuses more likely represent an underlying mucosal inflammatory process.



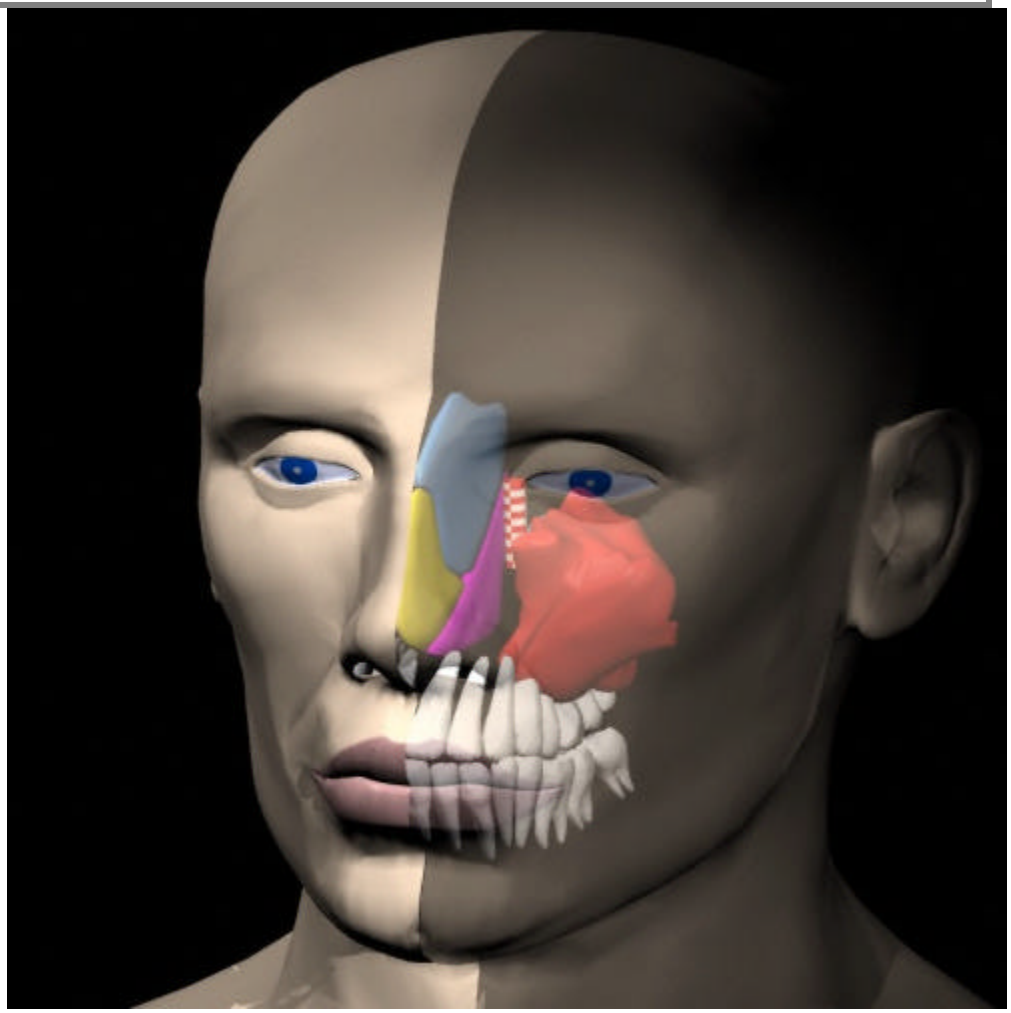
Sphenoid 1.
The sphenoid sinus is the most posterior sinus. An infected sphenoid sinus can cause posterior headaches. The drainage from the sphenoid is almost directly down the throat. Patients often complain of chronic cough and posterior headaches if the sphenoid is involved. The pituitary gland rests on the top of the sphenoid sinus.



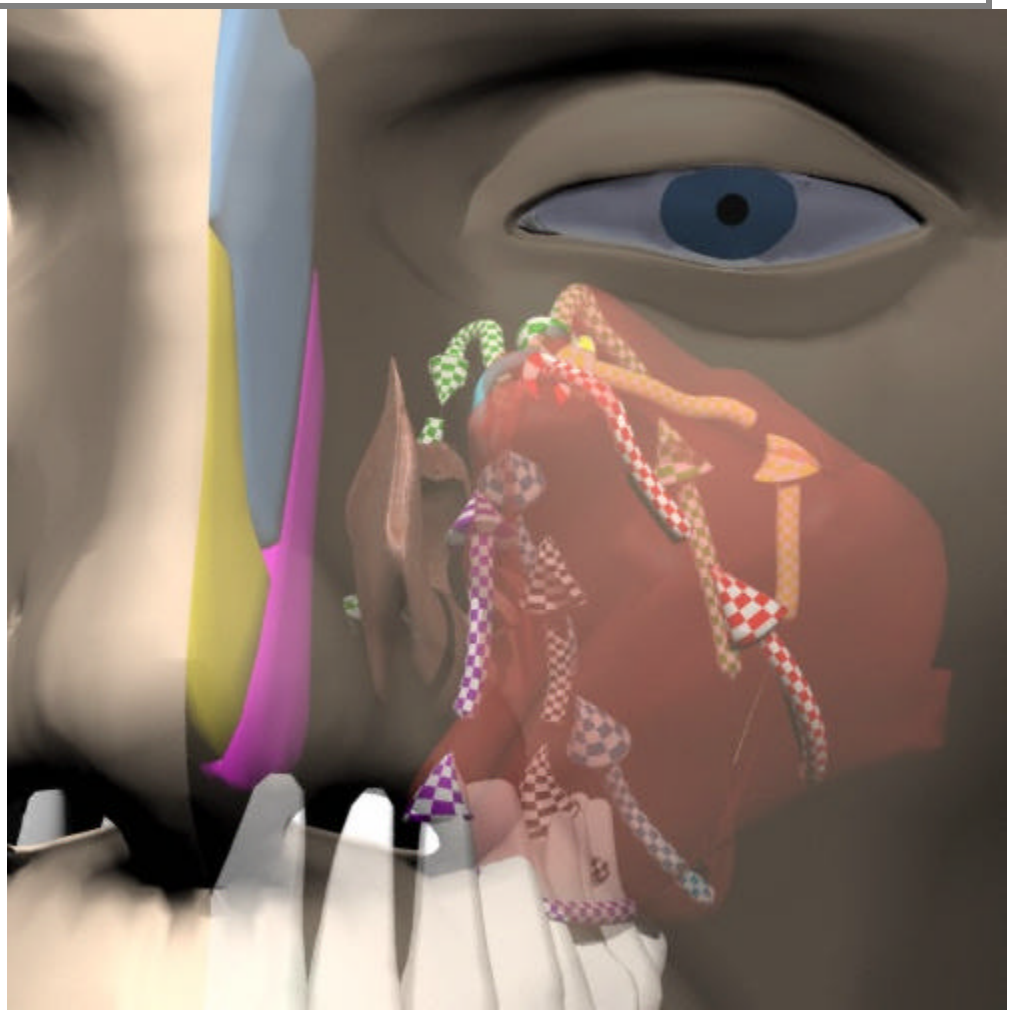
Sphenoid 2.
Both sphenoid sinuses are seen here. The left is partially transparent. The sphenoid sinus is adjacent to the main nerve that is responsible for vision, the optic nerve. The main artery that goes to the brain, the carotid artery, travels along the wall of this sinus.



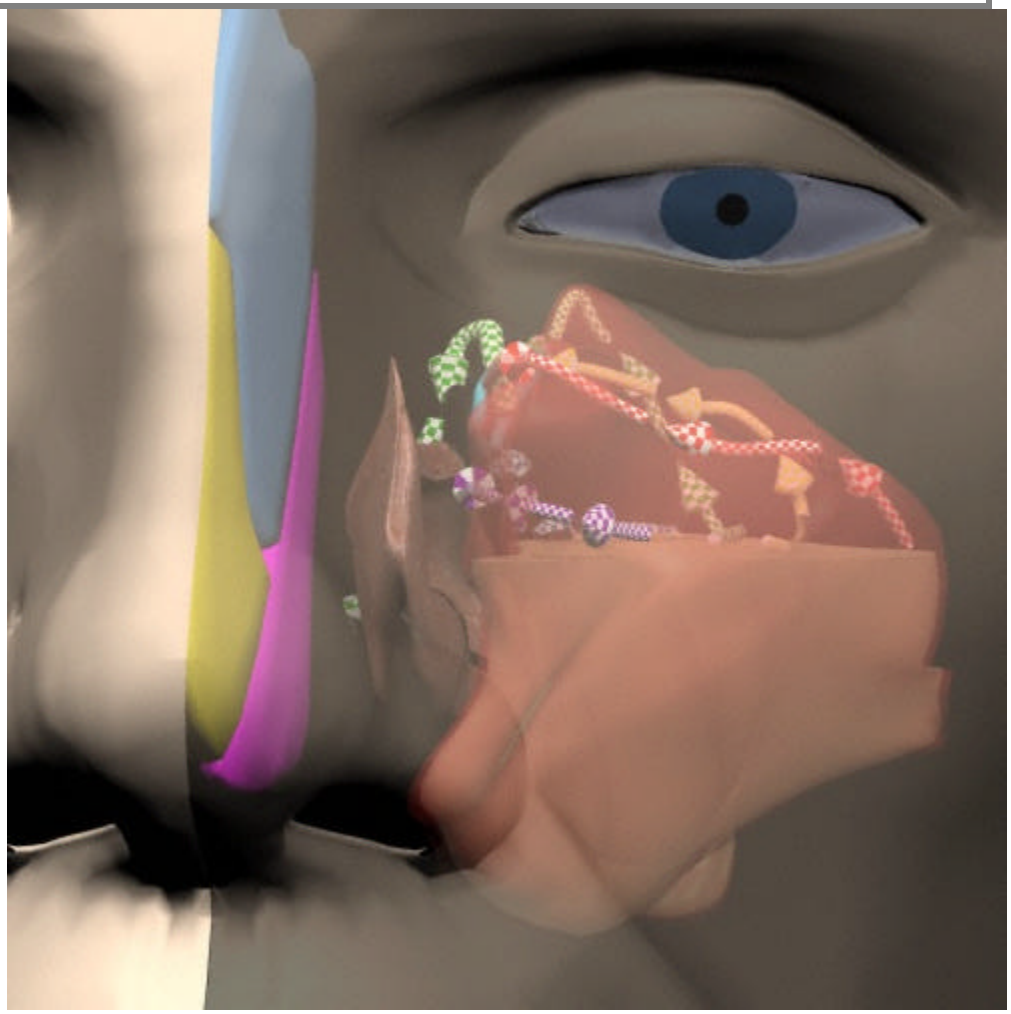
Maxillary 1.
The maxillary sinus is the largest paranasal sinus. It is intimately related to the upper teeth, tear duct, and the floor of the orbital cavity.



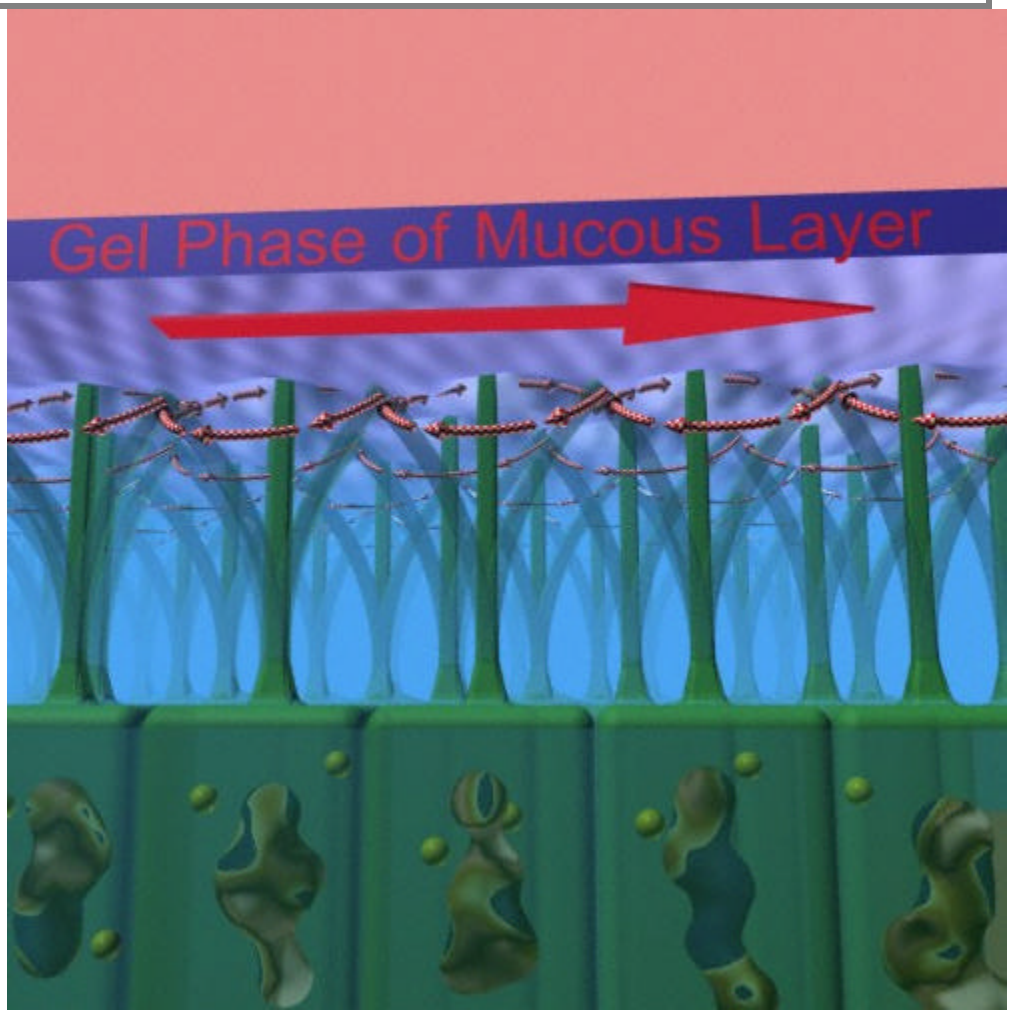
Maxillary 2.
The maxillary sinus must pump mucous uphill to reach the sinus opening which is at the top. This sinus has a large internal surface area and volume relative to the size of its outflow tract. The flow exits the sinus ostia, then traverses the uncinate process, and then drains over the top of the inferior turbinate.



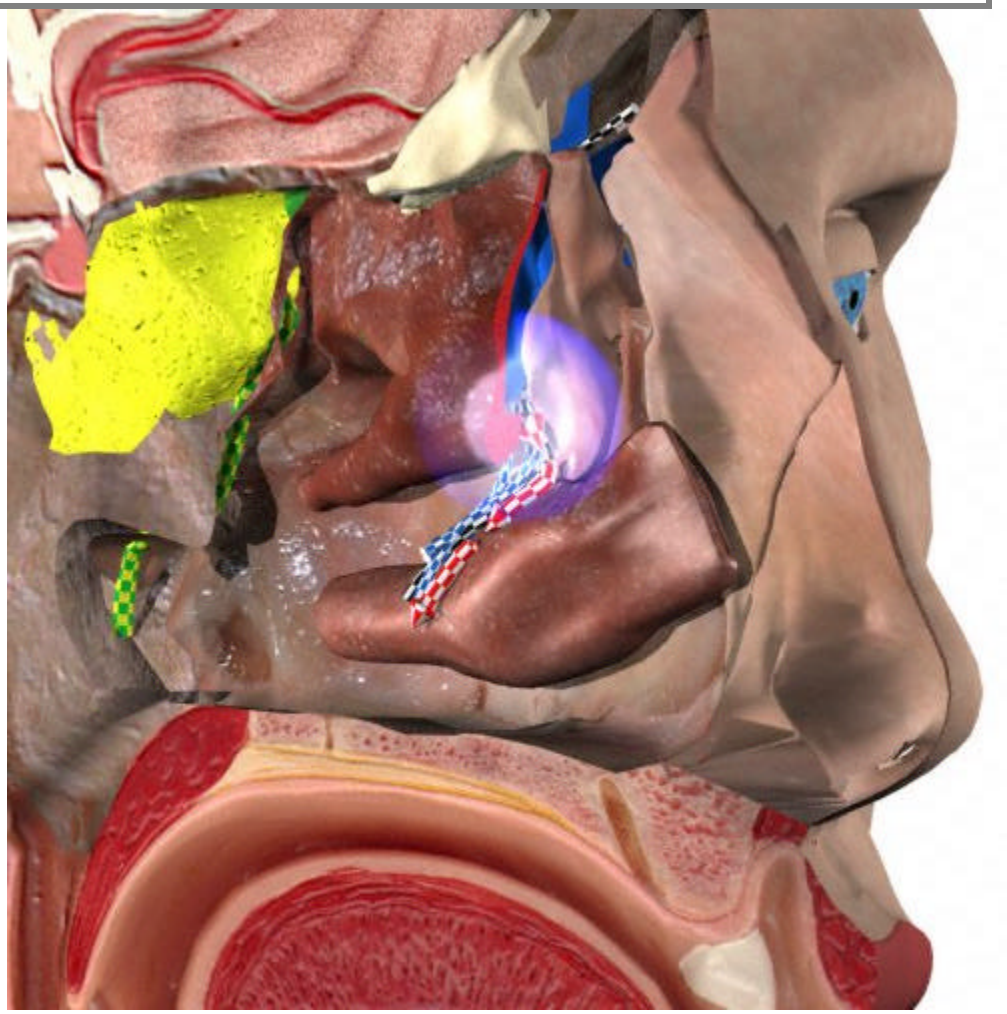
Maxillary 3.
During infections and sinus blockage, mucous or pus fills the sinus. Fluid is pulled from the surface of the fluid level and then transported to the exit. The surface area of the sinus cavity that is below the fluid level cannot provide useful mucociliary flow. It can be a fine balance between the rate that fluid is produced and the speed of the ciliary pumping mechanism.



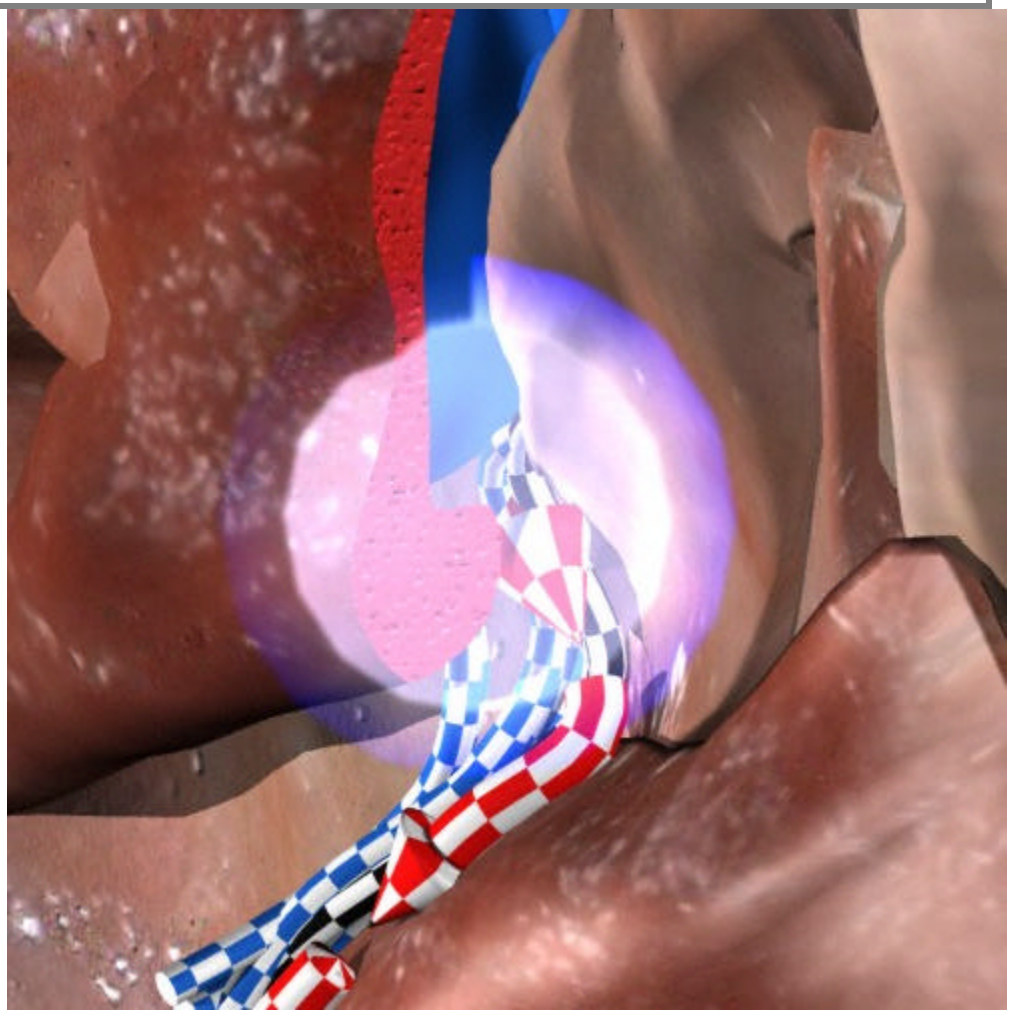
Cilia Motion.
The mucosal lining of the sinus is covered with hair cells that actively pump fluid towards the exit. The mucous that is produced by the lining of the sinus flows along in a specific path that is determined by the direction that the hair cells beat. In health, a thin blanket of mucous is constantly flowing along. The surface layer is in a gel type phase, the deeper layer is a less viscous phase, called sol.



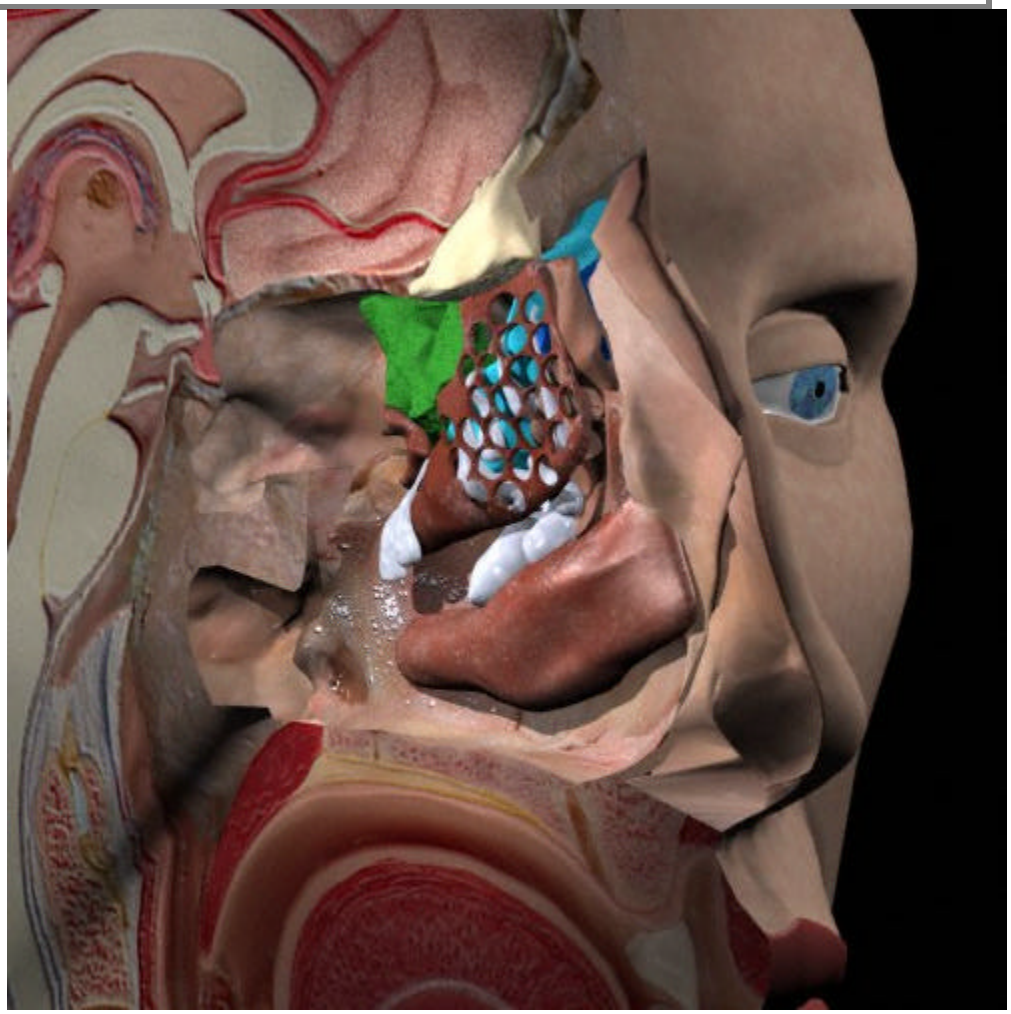
Os. Meatal 1.
It is thought that many sinus infections begin with swelling in the nasal cavity from viruses or allergies. This swelling may lead to obstruction of the all important ostiomeatal complex (blue glow). The ostiomeatal complex can be thought of as the main intersection for drainage from the anterior sinus cavities.



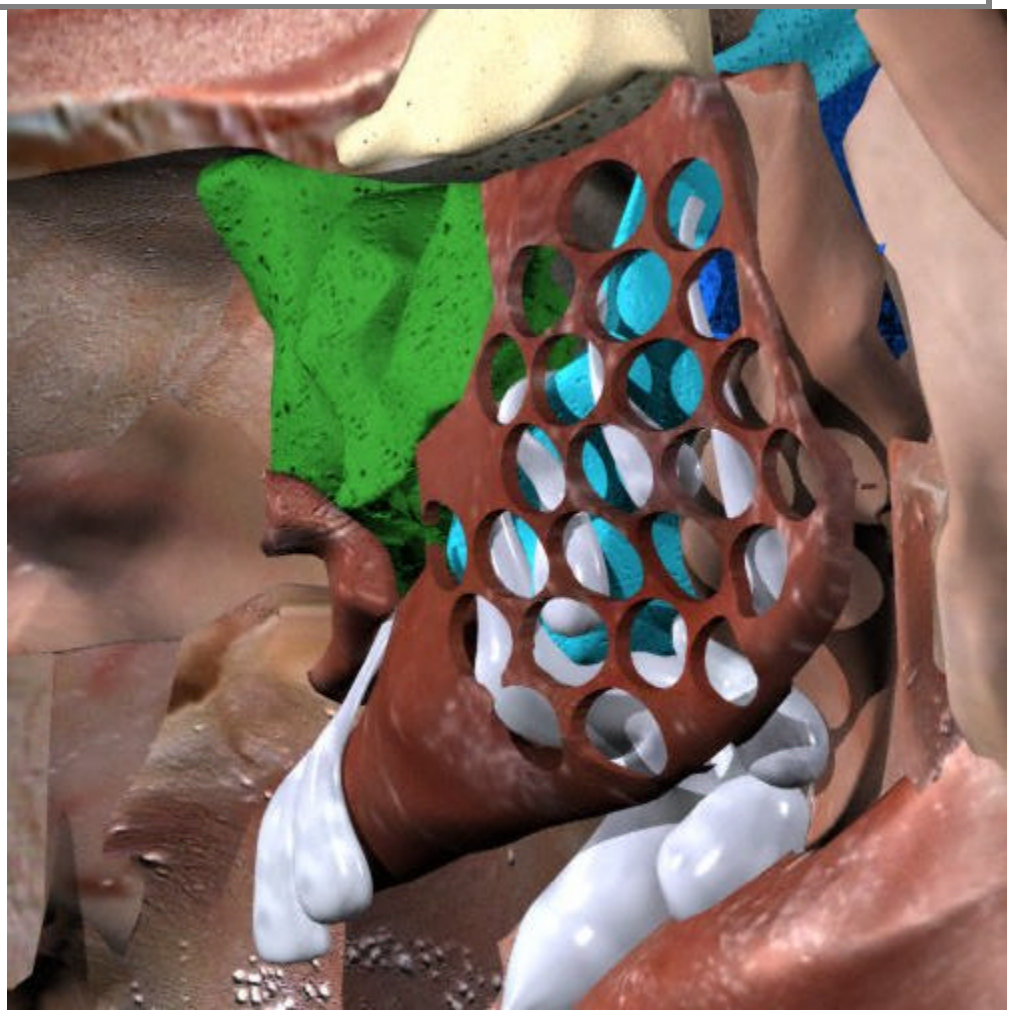
Os. Meatal 2.
The ostiomeatal complex describes a functional unit, not a specific anatomic structure. The most critical locations are shown in blue glow. If this area is obstructed, the mucous flow from the maxillary, anterior ethmoids, and frontal can back up.



Polyps 1.
In some cases, polyps grow into the nasal passage. They usually originate at the sinus openings. Polyps are like teardrop-shaped collections of inflammatory cells, fluid, and tissue. They are covered by a mucous membrane. They can grow in response to infection, allergy, locations of abnormal contact, or for unknown reasons. When polyps are widespread, it is usually from some underlying mucosal abnormality.

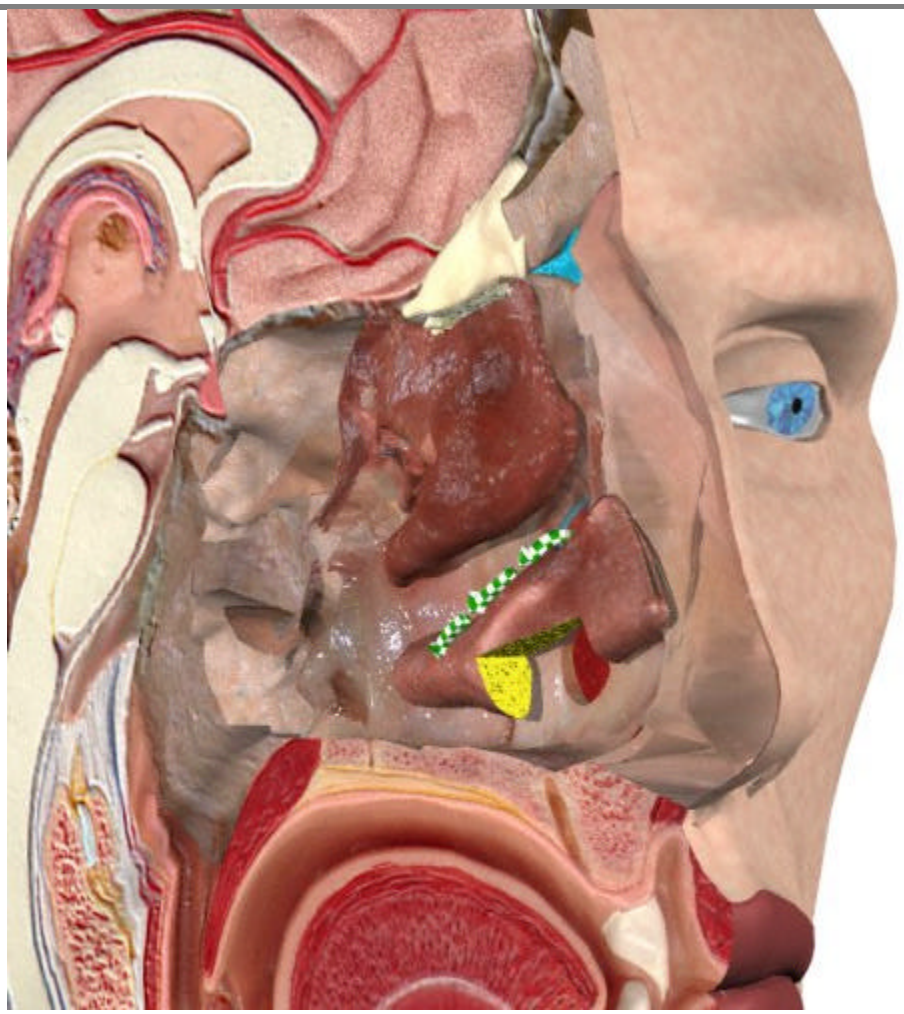


Polyps 2.
Polyps may respond to medications such as steroids. If they block breathing, interfere with sinus drainage, or cause other problems they may need to be removed. If infection or other local phenomenon is the underlying problem, the polyps will usually not return. If they originally grew as a result of allergic or non-allergic rhinitis, allergic fungal sinusitis, or if they are associated with aspirin sensitivity, they are more prone to return after surgery.

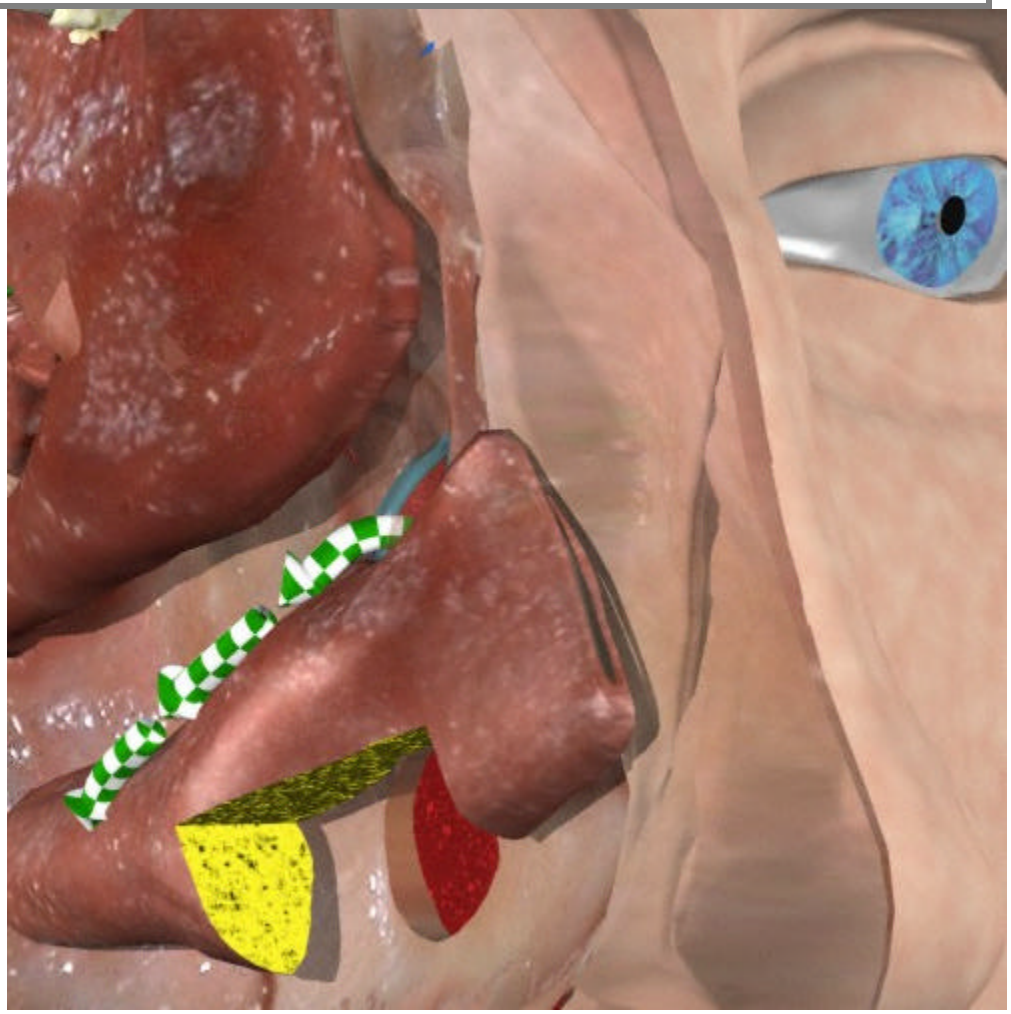


Windows 1.

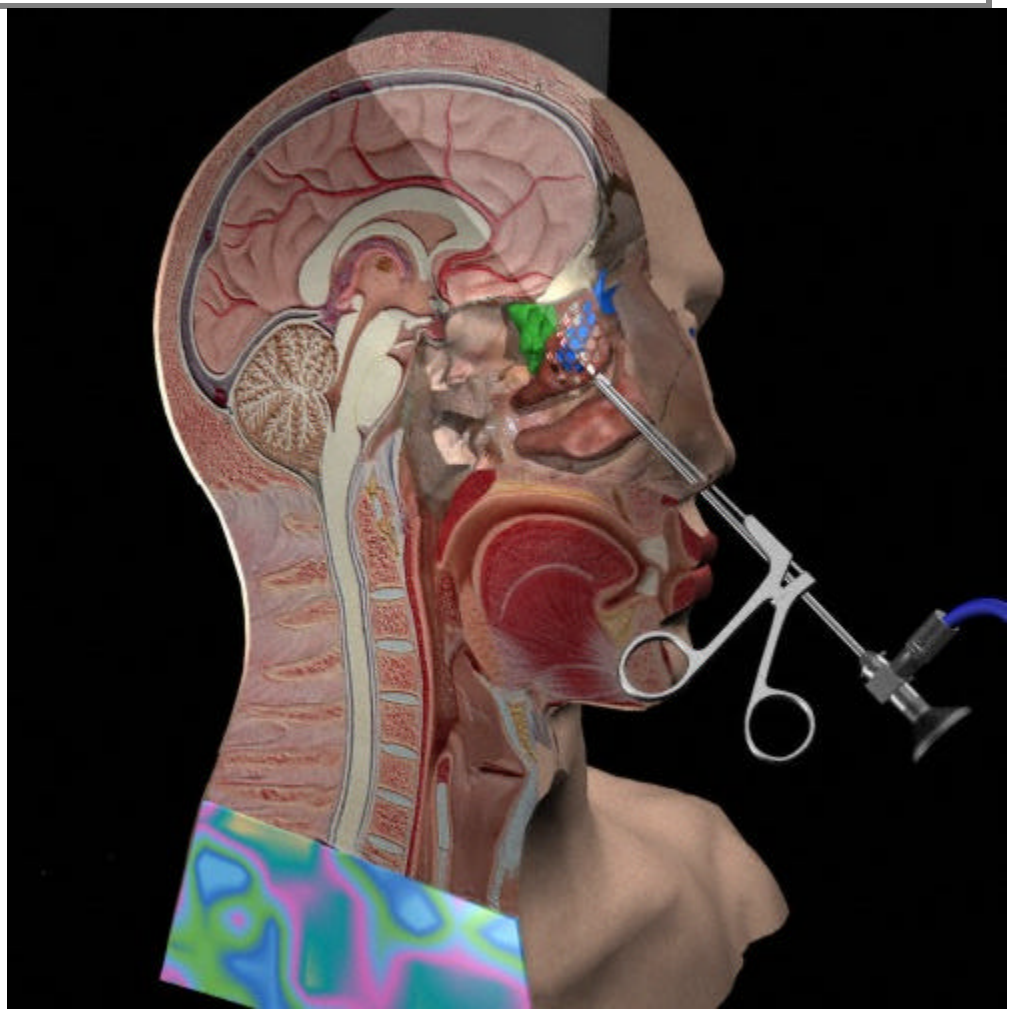
The usual goal of sinus surgery is to improve the drainage of the sinus cavities. For many years the standard operation was the naso-antral window. While this procedure often helped, the natural opening was not enlarged. Only the maxillary sinus was addressed. Problems often persisted because there was often ethmoid involvement, or because the new opening was not a functional drainage route.



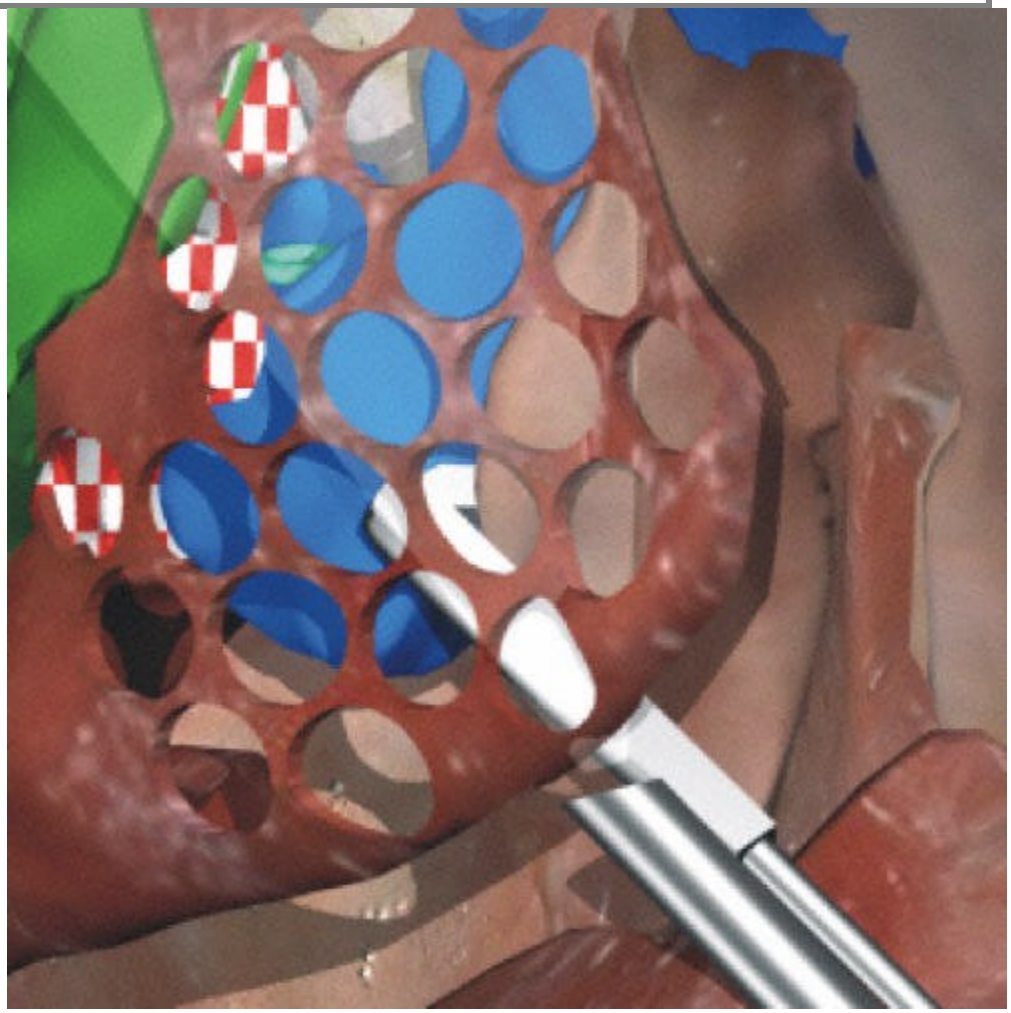
Windows 2.
The hair cells that line the sinus are programmed to direct mucous to the natural opening, and down the normal drainage pathway. If the natural exit is still blocked, mucous must accumulate at the natural “exit”, fall to the floor, and passively flow out of the surgical window



FESS 1.
Modern sinus surgery relies on narrow optical instruments called endoscopes. Endoscopes allow direct examination of the sinus openings, even into narrow spaces and around corners.

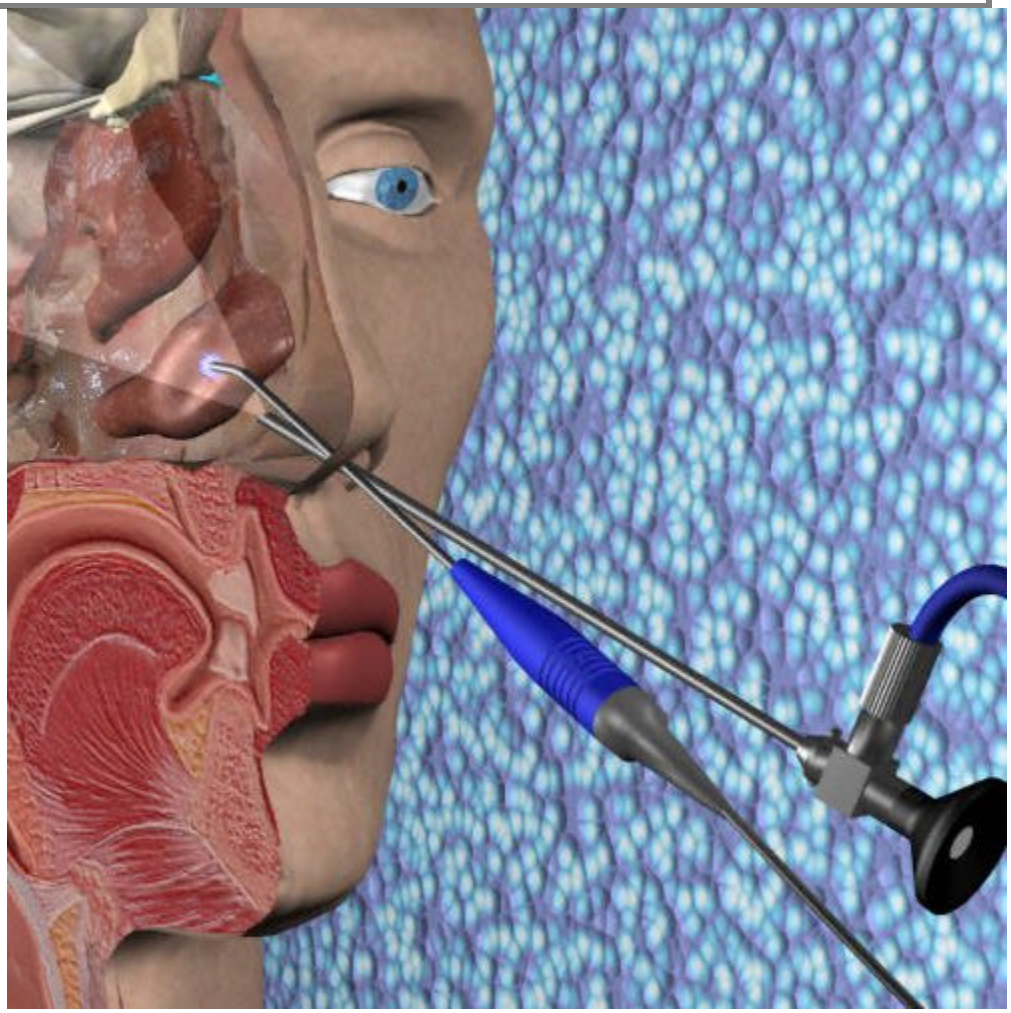


FESS 2.
Most endoscopic procedures begin with the removal of the uncinate process. The eggshell thin bone that makes up the uncinate process is seen being opened with a specialized instrument called a backbiter.



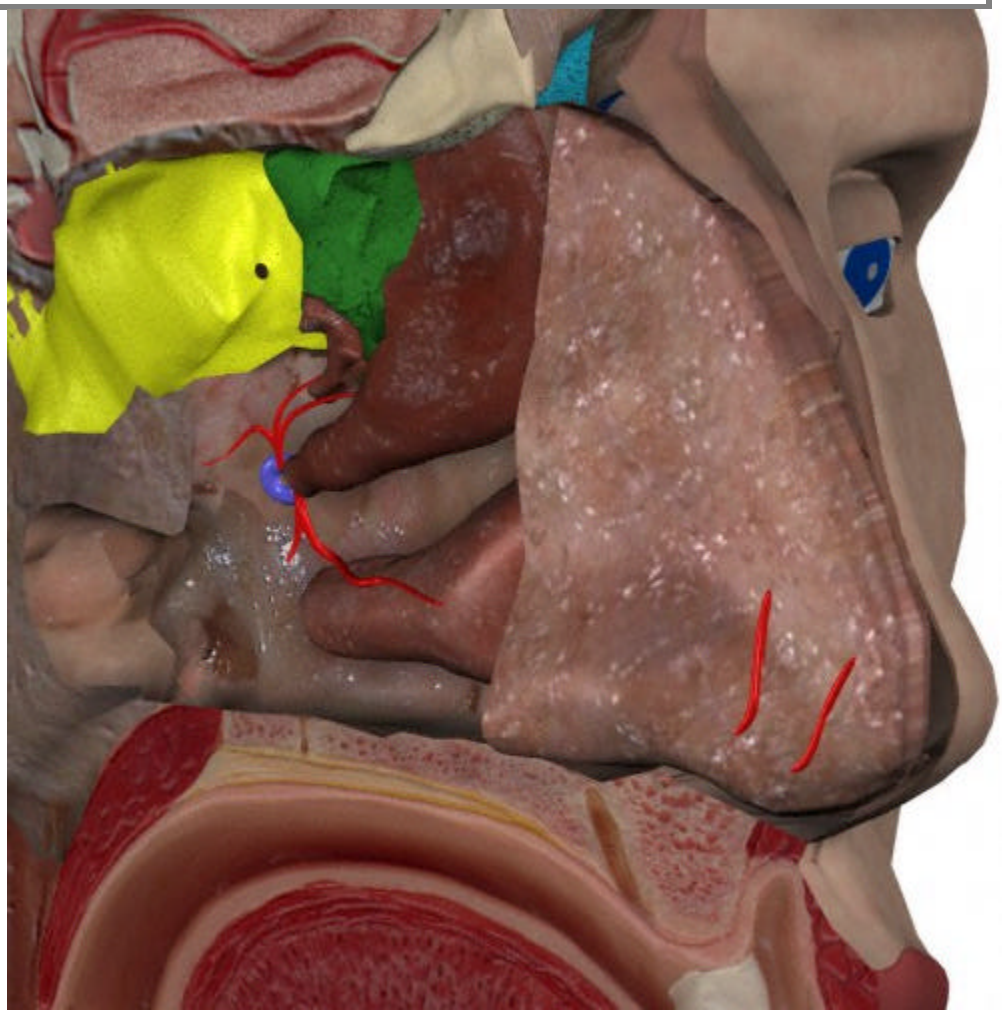
Reduce Turb.

Enlarged inferior turbinates are often the cause of chronic nasal congestion. Even after the underlying problem is addressed, such as chronic infection or allergy, the enlargement may remain. Below is a depiction of the new plasma generator wand. This instrument creates a high-energy plasma cloud at its tip and can be used to reduce the size of the inferior turbinate. The Somnus radio-frequency generator, and direct removal are other ways to reduce the turbinate. Different situations call for different methods.



Nose Bleed.

Nosebleeds can occur for various reasons, and from a variety of sites. The most common site of bleeding is from superficial blood vessels on the anterior nasal septum. Posterior nosebleeds are the most dangerous and difficult to control. The bleeding site is often related to vessels that enter the nose through the sphenopalatine foramen. Bleeding here can be controlled with posterior packing or endoscopic vessel ligation.



Cool Image.
This image series shows only simple anatomic structures. In my advanced lectures that are given to sinus surgeons, complicated anatomic principles can be explored. Here you can see the image-guided surgery system. This system imitates one used during endoscopic procedures. Wherever the pointer points, the corresponding CAT scan cuts are displayed. The CAT scan data can also be incorporated directly into the scene as shown. The scan at the level of the sphenoid is seen. The right sphenoid is partially transparent. An anatomic location called the hiatus semilunaris superior is demonstrated.